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DEPARTMENT OF AGRICULTURE.

MISCELLANEOUS. SPECIAL REPORT No. 7.

TIDE MARSHES

OF

THE UNITED STATES,

BY

D. M. NESBIT;

WITH

CONTRIBUTIONS FROM U. S. COAST SURVEY, S. L. BOARDMAN, ELDRIDGE MORSE, AND OTHERS.

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DEPARTMENT OF AGRICULTURE,
Washington, D. C., October 11, 1884.

SIR: A report on the Tide Marshes of the United States, from an agricultural standpoint, prepared by your direction, and aiming to present the subject in its practical bearings, is submitted herewith.

Acknowledgments are due to a multitude of correspondents, free use having been made, by abridgment, condensation, and rearrangement, or in generalizations, of many letters which could not, in harmony with the purposes and limitations of the report, be used entire. The obligations of the Department to correspondents have been recognized by the promise to each of a copy of the report. This may seem a slight return to be rendered to not a few gentlemen who have taken more than usual pains to furnish exact information in response to specific queries; but they have the satisfaction—to them doubtless a gratifying compensation—of having rendered a valuable public service. Had this spirit moved all to whom letters were addressed, some features of especial interest would have been brought out with greater distinctness, as will appear by reference to such letters, copies of which are filed with the matter received from correspondents. Nevertheless it is believed that this work presents much information relative to the tide marshes of our country, and their adaptation to agricultural uses, that has not hitherto been accessible.

I have the honor to be, very respectfully,

D. M. NESBIT.

Hon. GEORGE B. LORING,
Commissioner of Agriculture.

TIDE MARSHES OF THE UNITED STATES.

ANTIQUITY OF DIKING.

When or where the idea of diking marshes to prevent the overflow of tides had its inception, is not known. The nations of the Old World banked out the waters of their seas and rivers to make room for increasing population many centuries before Columbus crossed the Atlantic, and the early colonists from Holland, Sweden, England, and Scotland, with an unexplored continent before them, began the work of excluding the tides from the rich meadows bordering their rivers. The subject is not new; whatever claim it has to consideration must be found in its importance.

SCOPE OF THE INQUIRY.

This investigation is concerned primarily with the tide marshes of our own country and their reclamation for agriculture, though it contains a most valuable paper on the tide lands about the Bay of Fundy, prepared by Mr. S. L. Boardman; and an account of the reclamation of the English fens and Haarlem Meer, from the report of the State geologist of New Jersey, Prof. George H. Cook, is appended. The tides and the marshes of China, or India, or Holland, or England may not differ essentially from the tides and the marshes of America, but agriculture here finds no counterpart in the Old World. When our marshes shall be wrested from the tides, our political, social, and industrial conditions will warrant as well as demand the conquest, and its methods will be American. While the reader will miss the interest that would belong to a complete history of reclamation in all lands, or even in our own—for we shall have to do chiefly with our own times—it is hoped that a practical discussion of home methods, difficulties, failures, and successes will meet some reasonable doubts and objections that would find no answer in a treatise on the greater reclamations of the Old World. If this first attempt to focalize the light of home experience shall serve to attract attention to the extent and wealth of one of our national resources, as

yet mainly undeveloped, and in some measure mark the way to such development, the mission of this report will be accomplished.

In the category of tide marshes are included all marshes subject to overflow of the tides, whether regular or occasional, salt or fresh; from it are excluded all marshes above the altitude of the highest tides, regardless of liability to overflow by freshets. Tide marshes are those low lands of alluvial, peaty, or mixed formation, along ocean and gulf coasts and the shores of bays, sounds, lagoons, bayous, inlets, sloughs, creeks, and rivers, which are overflowed by the diurnal tides or by storm tides, so as to be unfit for cultivation until the tides are banked out. All tide marshes are above low water, and, other things being equal, their value depends largely on their elevation. Large tracts formerly covered at all stages of the tides have been reclaimed from the sea by means of costly dikes and expensive machinery for elevating the drainage water, but land always submerged is not strictly tide marsh, and its reclamation will not be considered here. Nor is the protection and improvement of marshes, swamps, and bottom lands which are above the highest tides relevant to this discussion, however they may be subject to overflow.

The line between tide marshes and other marshes may seem arbitrary, but is not entirely so. The characteristics of tide marshes are sufficiently distinct to constitute them a class by themselves, and their improvement a proper subject for separate consideration. Tide marshes invariably require the protection of banks or dikes higher than the tides; other wet lands only need such protection where they are exposed to freshets in the growing season. Generally (though not without exception) the ebb of the tide may be considered as affording the lowest possible outlet for land drainage. With this the drainage of tide marshes is most closely concerned, other marshes not at all. Tide marshes, especially fresh-water tide marshes, are to a much greater extent than others exempt from the destructive effect of droughts, and by reason of their location have an advantage in the transportation of produce and a disadvantage in liability to unusual storm tides. And so the list of differences might be continued, but enough have been enumerated to justify the present exclusive consideration of *tide marshes.* On the other hand, it must be remembered that there is much tide marsh which is not "salt marsh." Notable among reclaimed fresh-water tide lands are the rice fields of our Southern rivers and the banked meadows of New Jersey, which will be noticed further on. Fresh-water tide marshes are found along all or nearly all tidal rivers, the flow of the tides extending usually far beyond the salt water.

The reclamation of marshes for governmental, commercial, or any other than agricultural uses will not be considered, for such improvements are in a measure independent of the question of cost per acre, which is of prime importance to the farmer. For the same reason the preparation of cranberry lands is omitted.

Within these limits the subject will be presented as follows:

I.—Objections.
II.—Conditions and methods of profitable reclamation.
III.—A general survey.
IV.—Management of reclaimed lands.
V.—Legislation.
VI.—Areas, by the Coast Survey.
VII.—The tide lands of Nova Scotia and New Brunswick.
VIII.—The tide lands of Washington Territory.
IX.—Correspondence.—

I.—OBJECTIONS.

Objections urged against the reclamation of tide marshes have a wide range. It is even held, in all seriousness apparently, that an attempt to define the limits of the seas—to set bounds to the sway of the tides—is such an act of disrespect towards the Creator as must necessarily meet His disapproval and be visited with evidences of His displeasure. A field of discussion is here indicated which this report does not presume to enter.

Probably no one who has made a close study of the subject will be ready to pronounce against *all* reclamation by diking, even in our own country of abundant and cheap lands. That there are millions of acres of tide lands that cannot under existing conditions, and probably never will be, reclaimed, is freely conceded; but when one assumes to put aside the whole question of tide-land reclamation as being of no practical importance in this country, whatever his general information and ability to talk learnedly of the agriculture of the world and the crops of all nations, he simply proclaims himself in error so far as this particular subject is concerned. And yet there are just such men. In fact, the knowledge that tide land farming has anywhere in this country passed beyond the experimental stage is far from being generally disseminated even among people of intelligence. It is held by many that the exclusion of the tides is an impracticable thing. This idea prevails largely in coast regions where no diking has been done, and, singularly enough, is held by some in the immediate vicinity of diked lands that are regularly yielding their owners the most liberal returns. The movement of the tides day after day, year after year, impresses the constant beholder with the idea of irresistible force, and he forgets that all natural forces can be, have been, and are measurably resisted. Often this feeling is a result of an unfortunate attempt at diking. A burnt child dreads the fire, and no less if his misfortune is the end of a show performance. A case in point, not related in the correspondence from Delaware, though happening in that State, which has more diked lands in proportion to its area than any other, was that of a gentleman who undertook with some flourish of trumpets to show his neighbors "a thing or two" about making dikes and sluices. He had not given very much study to the experience of others, but was entirely confident that he knew how to make and set a sluice, and he did it according to his own ideas. After a time the east wind blew and a storm tide beat against that sluice, and the proprietor walked out on his dike to enjoy his vic-

tory. He sat on the sluice and watched the waters rising outside with serene satisfaction. Presently he was startled by a slight vibration of the timber, which grew rapidly into a swaying motion, and, just as he took a position on the dike, the whole sluice shot up like a cork. He admits that he addressed to that sluice, which so unceremoniously got above its business, some parting words that could not be construed into a benediction. He does not believe in diking now and rarely speaks of it. But the case is not settled against diking everywhere and for everybody.

But the notion that successful diking is impracticable is encountered away from the marshes. A gentleman learned and eminent in natural science, and so presumably having great respect for natural forces, suggested that this report should begin with the story of Canute. However apposite as an expression of his distrust of all schemes involving a contest with the tides, this little misadventure was so far away and so long ago that it must be reserved for a more general discussion. The "proud waves" of the sea, though they laugh at the fiat of a conqueror and play with his throne, respect a well-built dike and make terms with a skillful engineer. Some of the best lands of the island kingdom have been taken from the sea since the days of the doughty Dane, but not by his method. Many oversanguine and injudicious dikers have come to grief, and doubtless others will adopt their mistakes with like results, and the prejudice against diking will die slowly. If the reclamation of tide marshes demands a modicum of good judgment and watchfulness, it does not appear that it is singular on that account. Other operations in which men succeed are no less exacting.

It is reasonable to ask why, if reclamation is practicable and profitable, its progress has not been more rapid. There are obvious reasons. In all such operations a considerable outlay of money or labor, or both, is necessary before the marshes will yield any return; and American farmers and capitalists prefer, as a rule, to work for results that come quickly. Then, a certain amount of watchfulness must be maintained constantly, for the effort of the tides to recover their lost ground is unremitting. This perhaps more than any other consideration retards the improvement of tidal lands. In some cases ill-judged and badly executed attempts at reclamation have resulted in heavy losses, which a wider knowledge of the subject would have avoided. Thus many persons get an impression from a few failures that the whole business of reclamation is unsafe, and prefer to have nothing to do with it. Operating in the same direction with these causes, the railroads, which have been pushed to every corner of our domain, have brought immense areas of fertile lands within the reach of settlers and speculators at a cost hardly more than nominal. It is not strange that little progress, comparatively, has been made in the reclamation of tidal lands; and this fact does not constitute a valid argument against their value. We are coming rapidly to a time when other conditions will prevail. The day

of unlimited cheap lands is fast passing. Unless our growth meets a serious check there will soon be little available farm land unoccupied. Then advancing prices must furnish an additional incentive to the reclamation of our millions of acres of rich marsh land.

Others say "it will not pay" to reclaim marshes—a practical objection which cannot be argued away. Experimental proofs are demanded, and it is a part of the object of this report to show where and how diking is profitable.

Then it is said, "We have more dry land than we can cultivate; we don't need the marshes." Doubtless the premise is true, and it is far from the purpose of this report to advocate slack culture. This objection comes from those sections where the people, poor in pocket and bankrupt in enterprise, drive hard bargains with the starved soil for a living. No doubt they cultivate too much land, such as it is, and to add more of the same sort, with like culture, would be folly. The thing needed is not more but better cultivation, not more but better land; and if some worn-out fields should be covered again with forest trees there would be no loss.

The superiority of diked land over poor upland is nowhere better illustrated than along the Maurice River, in New Jersey. There the banked meadows, some of which have been in cultivation, without manure, for generations, are wonderfully fertile, and the upland immediately adjoining is only able to produce scrub oak and stunted pine, to which it is mainly given up. Yet nearly every meadow farmer has some old sand fields which yield hardly enough to pay for the labor put on them, with the manure from the farm-yard thrown in. The same manure applied to the meadows would increase their productiveness greatly, as has been shown by trial; but this is not the general custom.

Lack of means is an insuperable obstacle in the way of many who are fully aware of the unparalleled fertility of the marshes and convinced of the great profit that would, under favoring conditions, result from their reclamation. And this leads to the suggestion that progress in this work is to be expected chiefly under the management of men or companies with sufficient capital to inclose large tracts in the most perfect manner and drain them thoroughly. Reasons favoring individual or joint ownership of such large bodies of marsh as may be inclosed by one dike will appear throughout the report.

On the Gulf coast, particularly in Texas, we are met by a peculiar condition. The marshes are owned by the cattle-men, who value them even higher than fertile uplands for winter pastures. But, as will appear in the correspondence from that section, five acres are not furnishing the sustenance that one of such fertility should yield if Texas blue grass could be substituted for the native salt grasses. As the general value of land advances more will be expected of those marshes.

Objections on the score of health are hardly worthy of serious con-

sideration. Salt marshes are not insalubrious, and, as a rule, they differ materially in this respect from fresh marshes. The sanitary condition of the former is not improved by diking, nor are they rendered unwholesome if well drained. Marshes free from salt breed disease. During the first year of their transition into arable land they are no better but rather worse in that respect. After that there is no trouble from them. An exception, and the only exception, is noted in the case of rice culture, resulting from methods peculiar to that crop.

Next, and lastly, we come to the objection that the diking of tide marshes along navigable streams and about harbors is prejudicial to navigation. That it is so under certain conditions is beyond doubt. The reclamation at Marshfield, Mass., is a case in point. In view of the importance of this matter, a paper discussing the relation of reclamation to navigation, and embodying such facts and natural laws as are known to the gentlemen of the Coast Survey, was earnestly desired for this report, and application was made accordingly to the Superintendent of the Bureau. Up to the time of rendering this report no such paper has been received. In its absence we refer readers to Appendix No. 5, on the reclamation of tide lands and its relation to navigation, by Henry Mitchell, in the United States Coast Survey Report for 1869, which is the ablest discussion of the subject known to the writer, though, if it is not entirely impartial, its tendency is to subordinate agricultural interests to the interests of navigation in all cases, without always weighing the rival claims, and possibly to overlook some inherent rights of the owners of the marshes, and altogether to make this objection to reclamation on account of its relation to navigation seem larger than it is.

This subject has not had the attention which its importance demands at the hands of our national and State legislatures. It should be determined whether it is right and expedient to maintain a tide-water creek as a public highway for the practical benefit, as it is in many cases, of one or at most a very few persons and to a very small extent, and thereby prevent the conversion of thousands of acres of insect and pestilence breeding marshes into fields and meadows.

The relation of reclamation to navigation should be made the subject of a most careful and thorough investigation by the General Government, and pending such investigation marsh lands on navigable streams belonging to the United States or to the States severally should be sold, subject to such conditions as would afford proper protection to the interests of navigation.

But the best marshes are, as a rule, owned by individuals who hold undisputed titles. Of course the Government can by right of eminent domain condemn private property, and tide marshes are no exception. Where the improvement of such marshes would destroy or imperil superior interests they should be taken at a fair valuation and held by the Government, State or National. But it has been proposed, apparently in all seriousness, without condemnation or compensation, to

abridge or deny the right to improve the marshes in all cases where such improvement might be prejudicial to the interests of navigation. This doctrine seems to be implied, though not definitely asserted, in the most valuable discussion by Prof. Henry Mitchell already referred to. The destructiveness of river freshets at any given point is increased by preventing overflow at points above, but it is not contended the man up the river may not on that account protect his property. Fifty years ago ocean vessels went up the Anacostia to Bladensburg. Now it is barely navigable on the tide by sand barges. The silting of this stream is traceable directly to the cultivation of its water-shed. Had that remained in its natural condition, that is, forest, the stream would have continued navigable. Yet it is not proposed to abridge the right to cultivate the soil.

Whatever may be determined regarding *rights*, it is confidently believed that the variance between the respective interests of reclamation and navigation has been exaggerated, and that in many cases they substantially agree. The most careful inquiries addressed to men familiar with reclamation work in all parts of our coasts where such work has been prosecuted fail to invest this objection with that degree of importance which it assumes in theoretical discussions.

II.—CONDITIONS AND METHODS OF PROFITABLE RECLAMATION.

The first step in reclamation is directed toward the exclusion of the tides, streams from the upland, and water of infiltration. This is the object of diking. The next is the removal of the excess of water from the soil, whether it result from heavy rain-fall, springs, or imperfect dikes. This is drainage. Then follows the preparation of the land for cultivation, the amelioration of the soil by exposure to the air, and in the case of salt marshes the leaching out of salt by flooding with fresh water.

Profitable reclamation depends on (1) the character of the land, (2) the cost of reclamation and maintenance, and (3) the home value of the products and such other conditions as apply equally to all farming in the locality under consideration.

The best marshes are alluvial, and the same principles apply in determining their value as in the case of bottom lands generally, which it is not needful to discuss here. A close relationship exists between the diked lands and the gypsum beds of the Bay of Fundy; between the banked meadows and the marl banks of West Jersey; between every tide marsh and its constituents. The tides deposit such materials as they get. If the materials are fertile, so are the marshes. There is no transmutation, no magic.

But alluvial tide lands are not all available for reclamation. In the southern portions of Texas and California, for instance, are immense tracts of such lands absolutely worthless for agriculture. They are charged with salt, and there is neither rain nor river to freshen or irrigate them.

Then there are peat marshes of all grades, some hardly less valuable than the best alluvial marshes, others of no value. These are so fully discussed in the correspondence from the different States, particularly Delaware, that no further reference to their characteristics is necessary.

The cost of reclamation and maintenance depends on the marshes themselves, and on their relations to the tides, to the water-shed, and to destructive forces.

The reclamation of a marsh having a frontage of a mile or more on tide water might cost more than its value, while an equal area protected by a few rods of dike would be exceedingly profitable. As a rule the

mud of alluvial marshes is the best possible material for the construction of dikes, and by far the cheapest. In exceptional cases it becomes necessary to bring material from a distance, and the cost is thereby greatly enhanced. Peat does not make substantial dikes, and a marsh which will not support a dike without piling is not likely to repay the cost of reclamation.

The elevation of a marsh above mean low water and its depression below the highest storm tides are matters of the gravest importance. On the latter depends almost entirely the cost of the dike, and the former determines the question of drainage. As a rule the reclaimed marshes of this country are near the level of mean high water; consequently where there is a large tidal action, as in Puget Sound, automatic drainage is easy and may be nearly perfect. Oftener the tidal action is so slight that thorough drainage is difficult, while on the Gulf coast and the shores of many of our sounds it can only be secured by the use of machinery. This subject is considered by several correspondents, especially Messrs. Ferris, of California, Watkins, of Louisiana, and Colburn, of Delaware, and a report on "Drainage of Kingsessing and Tinicum Meadow District" (in Pennsylvania) is copied as Appendix No. 2.

At exposed points on the coast high storm tides preclude the possibility, not of reclamation, but of profitable reclamation, under present conditions. The cost of erecting sufficient dikes would far exceed the value for agriculture of the reclaimed lands; and so on many tidal rivers, near the head of tide, and on some throughout their tidal course, as the Skagit, freshets constitute a like obstacle. The safest point on a river is above the reach of heavy storm tides and below the range of high freshets, particularly where they occur in the growing season.

The water-shed must also be considered. If it discharges through the marsh, the outlet must be diked back to the upland or dammed and the water vented through a sluice, either of which courses will add materially to the cost of the reclamation.

The destructive forces which tend to augment the cost of maintenance of dikes and ditches are so fully treated in the correspondence as to need no discussion here.

Manifestly the home value of agricultural products, and such other conditions as apply equally to all farming in any given locality, must go far toward determining the result of any proposed reclamation. The home demand for hay and oats which the Puget Sound marshes were so well fitted to supply had much to do with the phenomenal improvement of those marshes. But this is a thought which it is intended to suggest rather than develop, in anticipation of the teachings of experience as detailed in subsequent pages.

Briefly, the conditions favoring success are: (1) Good marshes, high enough to afford perfect natural drainage; (2) exemption from destructive freshets and storm tides; (3) thoroughness in dikes, ditches, and

sluices; (4) a good market; (5) individual, or at least harmonious, control (which is not always possible in associations of owners, whether forced or voluntary), all of which may be summed up, for a man or company proposing to buy marsh lands to reclaim, under the head of intelligent, capable, energetic business management. With this requisite reclamation affords fine opportunities for profitable investment, without it unbounded facilities for sinking money.

The best method of reclamation is the most thorough. A slight dike where a strong one is needed, a leaky sluice, and insufficient drainage are always unsafe, unsatisfactory, and unprofitable. Cheapness has always in this country been a very costly feature of reclamation. The recent adaptation of steam-dredges to draining and diking is working a revolution which will lead to the investment of capital in marsh reclamation to an extent not hitherto thought of. Messrs. Ferris, and Williams & Bixler, of California; the Louisiana Land Reclamation Company and Mr. Watkins, of Louisiana; and Mr. Colton, of the National Dredging Company, all pioneers in this work, have, upon invitation, furnished statements of operations under their management or observation, which are commnded to the reader.

The various methods of reclamation prevailing are presented in such detail elsewhere as to need no further discussion here.

In considering different and apparently contradictory methods and widely divergent estimates of cost, the attentive reader will not fail to note such local conditions as character of the marsh, its elevation, the tidal action, salt or fresh water, destructive forces, &c., which often fully explain the methods adopted and the degree of expense incurred. Still, differences of opinion remain among practical men, the presentation of which is not the least important of the objects of this work.

III.—A GENERAL SURVEY.

The soil of tide marshes is composed of sediment and drift, mingled with the remains of local animal and vegetable life. The alluvium of tide marshes differs in composition and value, as in all bottom lands. Generally it is very fertile when relieved of salt and an excess of water. In some places the fertile soil extends to a great depth, but not infrequently it rests near the surface, on sand or peat, and in many marshes the vegetable matter so predominates throughout that they are of little value. These are called peat marshes.

The supposed subsidence of lands along the coast and the enroachment of the ocean, though intimately related to the formation of tide marshes, have little bearing on the problem of reclamation. They may be studied in the reports of the United States Coast Survey or the geological survey of New Jersey.

Tide marshes are not peculiar to any portion of our coast. Every State and Territory with a frontage on tide water, whether of ocean, gulf, bay, sound, or river, has its marshes. If the only tide marshes were those bordering the Atlantic, the Gulf of Mexico, and the Pacific, their aggregate would be large and their reclamation a problem of great interest. These, however, are smaller in extent and less valuable than the marshes farther inland, on sounds, bays, and tidal rivers. Many of the latter are 200 miles or more from the ocean, as the famous Potomac Flats at Washington, the marshes of the Chesapeake above Baltimore, and the extreme portions of the Puget Sound region. Reasons for the greater value generally of inland tide marshes, in comparison with those on the coast, will be considered in another connection.

The width of tide marshes varies from the narrowest margin to many miles, and their contour is so irregular that the most careful estimate of the whole area of such lands, not based on actual survey, must necessarily be only a rude approximation. Mr. T. S. Gold, statistical agent for Connecticut, places the area of tide marshes, chiefly salt, of that State at 18,000 to 20,000 acres. The geological survey of New Jersey puts the area of tide marshes in that state at 295,474 acres, and Delaware, on similar authority, is credited with 100,000 acres. Pennsylvania, on the authority of Mr. E. N. Black, who alone has 1,000 acres under dike, has about 24,000 acres lower than high tides. In Washington Territory the amount probably does not differ much from 260,000 acres. These figures are intended to include diked lands along with unimproved marshes. The most careful research has failed to elicit re-

liable statistics of areas in the other States, excepting such as are furnished by the Coast Survey. There are no well-defined and recognized lines separating tide marshes from higher marshes or from such flats as are at a lower level, and so millions of acres are included as tide marshes, or excluded, depending on where these lines are drawn. An estimate of the whole country, excepting Alaska, of 10,000 square miles —between 6,000,000 and 7,000,000 acres—of tide marsh is entirely safe, and probably does not much, if at all, exceed the area of such as might be reclaimed with profit—an area nearly as large as the State of Vermont, while New Hampshire and New Jersey separately, or Massachusetts and Rhode Island combined, are smaller than this aggregate of rich alluvial lands along our coasts.

For convenience the coast is divided into five sections. It will be noticed that reclamation has nowhere been so popular and uniformly profitable as with the pioneers on the shores of Puget Sound. The exceptional conditions prevailing there are fully presented and explained in the correspondence from that region, and particularly in an abridgment of an exhaustive paper by Mr. Eldridge Morse.

1. THE NORTH ATLANTIC COAST.

The tide marshes from Passamaquoddy Bay to New York Harbor have been divided and subdivided from generation to generation, and are, as a rule, held in small lots by many owners. Several causes have tended toward this result. The marsh areas are small as compared with other sections of our coast. The population has from the first settlement been (comparatively) dense and the people frugal and thrifty. The long winters of New England required a large supply of forage, and the marshes produced it in quantity at least, and so there was a demand for the marshes. The winter's store of salt hay was not forgotten by the farmers on Thanksgiving Day, nor rated as the smallest of their bounties, though there is a tradition that an old farmer here and there, not blessed with a devout mind, went haying on the marshes every fall for a frolic, with a jolly party and a jug of old-time rum. However that may have been, the best of the salt grass was cut, cured, and fed to stock. Much of the marsh was not firm enough to support horses or cattle, but before the introduction of haying machinery that was not a serious drawback.

The cost of making salt hay now is relatively much greater and its intrinsic value for feeding is rated lower than in the old times. As a consequence the value of the marshes has materially declined. But they are still owned in small lots, and herein lies the greatest obstacle to their reclamation; for reclamation, to be profitable for agricultural uses, must embrace considerable tracts under one dike; otherwise the cost of diking exceeds the profit of farming. In all attempts to reclaim marshes belonging to many owners in the New England States endless

confusion, misunderstandings, and quarrels have arisen. Then there are in our Northern tide-water region few large alluvial tide marshes favorably situated for reclamation. The rivers of New England do not, like those of the Middle and Southern seaboard, flow through wide fresh-water tide marshes, and a much larger proportion of the tide marshes are salt marshes—so much so that "salt marsh" has come to be a confusing popular synonym for "tide marsh." The marshes are generally narrow, or very peaty, or exposed to destructive storm tides, or held by many owners, so it is not strange that little comparatively has been done for their reclamation in a section where we would naturally look for its largest developement if intelligence, thrift, and wealth were the only requisites.

In Maine the most important reclamations are in Washington, Cumberland, and York Counties, and in Massachusetts at Marshfield, in Plymouth County. Of these, interesting accounts will be found in the correspondence from those localities.

In Connecticut, a reclamation of some note was made by Hon. James Bill many years ago. Mr. Bill has kindly furnished a statement concerning it, to which attention is invited. Whatever may have been the causes of his ill success, it does not appear that lack of means was one of them. Enough has been done on the New England coast to show the feasibility and profit of reclamation under favoring circumstances. That more will be done is beyond doubt; but the great development of the near future will, for reasons which have been sufficiently elaborated, be elsewhere.

2. THE DELAWARE AND CHESAPEAKE BAYS AND THEIR TRIBUTARIES, AND THE NEW JERSEY COAST.

The reclamation of salt marshes near Newark, N. J., attracted no little attention some fifteen years ago, and it is not thought needful to add to what has been published (in the report of the Department of Agriculture for 1870, the annual report of the State geologist of New Jersey, and elsewhere) on that subject.

Southward, to Cape May, are immense stretches of salt marshes, and along a few of the rivers no inconsiderable tracts of fresh tide marsh lying waste. In the northern part they are exposed to such storm tides as will for a long time preclude general reclamation. Farther south they are protected by sandy beaches, which are separated by bays and lagoons from the mainland. Here the tidal action is generally small, and more or less of the drainage water must be lifted by machinery if they are reclaimed. The marshes have never been subdivided to any such extent as in New England, and may be purchased at prices which will warrant their improvement.

More than twenty years ago the writer first visited the banked meadows of Maurice River. They were then and had been for many years

producing heavy and regular crops, without manure. The system of rotation most approved was to plow a timothy sod of five or six years' standing and plant corn. In the fall timothy was sown with winter grain or alone, and hay was the crop until the meadow was again broken for corn. This rule, not invariable though generally followed, was equally well adapted to the land and to the home market (Millville, the principal town on the river, being a manufacturing center) and required little labor. It was a common practice to apply, each time the sod was broken, about 50 bushels of shell lime per acre. The crops of corn ranged from 50 to 100 bushels (shelled) per acre, and of hay from 2 to 3 tons. The supply of water was controlled by the tide-gates and the land was exempt from drought. At that time all crops on the uplands were parched, yet the meadows had not suffered in the least.

Last July the meadows were revisited. The same regular cropping had continued during the interval, and the crops were in all respects equal to those of twenty years before. There was nothing sensational, nothing experimental, and apparently nothing uncertain. Farming there was, to one not a novice in farming, strikingly suggestive, as an occupation, of clipping coupons from Government bonds. To the farmers there it was a matter of course; they seemed to see nothing very remarkable about it.

The meadows of the Maurice River cover thousands of acres of varying quality. Some, even of the best, have not been banked, and of those once cultivated large tracts are now lying out. The banks, always insufficient, were left to the muskrats, with the inevitable result. Then the owners, failing to agree about repairs, or some of them lacking the means, did nothing. But the meadows have been improving all the time by deposits of mud, and stand ready to resume their bountiful service, only asking that the breaches be repaired.

The banks along the Maurice River are all hand-made. Some day they will be strengthened and at the same time the narrow channel of the river improved by steam-dredges. Then the muskrats can make their burrows without letting the water in, and almost the only cause of insecurity will be removed, though this insecurity, as it is with the present dikes, does not amount to a very serious matter with any man of moderate efficiency. The muskrat is not malicious, and does not work to see the water run, as some suppose. He burrows for a home, and the leak is an accident. Some owners give exclusive privileges to trap and shoot to one man, who in return keeps the muskrats down to a minimum.

So great is the interest attaching to these New Jersey meadows that liberal extracts from annual reports of the State geologist of New Jersey (Prof. George H. Cook) are presented in an appendix.

The tide marsh of Pennsylvania is nearly all below Philadelphia, on the west side of the Delaware River. It is all fresh and generally of excellent quality. Mr. Edgar M. Black, whose farm of 1,000 acres on

the bank of the Delaware, below the mouth of the Schuylkill, is all below high tide, has given much thought to the reclamation of tide marshes, and has been very successful. He has kindly furnished a statement, to which the attention of readers is particularly invited.

In Delaware, marshes were diked by the Swedes nearly or quite two hundred years ago. The percentage of diked lands is greater than in any other State, and yet immense tracts of good marsh are still lying waste. Mr. Budd, the statistical agent of the Department of Agriculture for Delaware, several gentlemen interested in tide lands, and Mr. F. B. Colton, of the National Dredging Company, contribute much interesting matter relative to the marshes of Delaware.

Maryland and Virginia, with marshes of immense area, have done nothing worthy of note toward reclaiming them excepting in a few instances on James River.

In the District of Columbia reclamation is confined to Government work on the famous "Flats," which are being bodily raised above high-water mark, but not for farming.

3. THE SOUTH ATLANTIC COAST.

This division, extending from Cape Henry to the Florida Keys, embraces the diked rice fields of the Carolinas and Georgia, almost the only tide lands within these limits that have attracted much attention. These rice lands are, with small exceptions, inland; that is, not immediately on the coast, but bordering the rivers far enough from the ocean to be exempt from high storm tides, and (if not entirely above salt water) so situated that they can be flooded with fresh water from tributary streams. The upper limit is where the tidal action becomes insufficient to afford necessary drainage through sluices (pumping machinery not having been employed to any considerable extent), or where the liability to damage from freshets is too great to be contended against.

Within these limits many thousands of acres of timbered and open swamps and marshes were diked, cleared, and prepared for rice culture, at a cost reaching in some cases $200 per acre.

These rice lands yielded greater and surer returns on the capital invested than any other agricultural lands in the country. In its prosperous days the rice interest was of immense value. One of the effects of the late war was to break it up almost entirely. Thousands of acres were abandoned, the dikes destroyed, the ditches filled, and the land allowed to relapse toward its original condition.

The restoration of these lands demands energy and capital, and many of the old planters, impoverished and dispirited by the war, are unequal to the task.

Much of the old rice land has been brought under cultivation again, but more is still lying waste, and perhaps, so far as rice is concerned, likely to remain so.

In view of these conditions, inquiries were addressed to many gentlemen interested in the old rice lands to ascertain what, if anything, had been proved by experiment regarding the adaptation of these lands to general farming and particularly to the production of hay; and while everything favors the belief that these lands would produce heavy and unfailing crops of excellent hay, which would be in demand in the Southern seaboard cities and for export to the West Indies and elsewhere, at prices which would afford exceedingly liberal returns for the investment, while the production of hay on a large scale would be independent of the unreliable low-grade labor which the rice planter has to contend with, and free from the objection of unhealthfulness (because there would be no flooding in warm weather), yet there are few experiments to be cited in support of these conclusions. Enough has been done and observed to put it beyond a doubt that timothy and other of the finer grasses will thrive on these lands when suitably drained, as they do on the diked marshes along the streams that flow into Delaware Bay, and on similar "blue mud" lands everywhere. The fact that these better grasses are not often found growing in the rice lands is only an attestation of their well-known character. They are not aquatic plants. They must have a drained soil beyond what is required for rice. And this in most cases is easily secured. The winter freshets need not be excluded; they do no harm to the grass, and their sediment is of immense value. There is not a reasonable doubt that the production of hay on these lands on a large scale, as a business enterprise, would be both sure and profitable.

That they will ever be entirely restored to rice culture is doubtful. Upland rice-growing requires little capital, is remunerative and increasing. And if the great schemes for rice-growing in Louisiana should prove even moderately successful, the old rice fields of the Atlantic rivers will compete with them somewhat as do the small farms of the East with Dakota or California in wheat-growing.

There are immense areas of river and sea tide marsh from Virginia to Florida that have never been improved or used in any way. The greater part of the sea coast from Cape Henry to Cape Fear is a succession of sand ridges known as "The Banks."

These are separated from the mainland by wide sounds, which disperse the tidal action communicated through the narrow inlets, so that the marshes along their shores and up the tributary rivers are but little affected by regular tides. The action of the tide is not sufficient to secure automatic drainage. They may, and doubtless will be, reclaimed profitably some day, but the drainage water must be lifted by machinery. They are considered of little value excepting where wild fowls abound. Back of these are fresh-water swamps, extending far inland at many places, which could be drained by digging canals to tide water. These, like the tide lands, are waiting for improvement.

From Cape Fear to Florida, bordering the lower parts of the rice

rivers, along the coast, and on the sea islands, are thousands upon thousands of acres of wild salt marsh, much of it of good quality, protected from high storm tides and with sufficient tidal action to secure good drainage. Small tracts reclaimed produce excellent sea-island cotton and other crops, and the productive area could be indefinitely extended. There is valuable information concerning this entire division of the coast in the extracts from correspondence.

Rice culture never extended far into the Florida peninsula. On most of the marshes the tidal action is insufficient for natural drainage, and the inland swamps afford the most attractive fields at present for enterprise.

4. THE GULF COAST.

The country bordering the Gulf from Cape Sable to the mouth of the Rio Grande is low, and marshes extend far inland, covering millions of acres. Near the Gulf, and affected directly by the diurnal tides, are the salt marshes; back of this belt the marsh water is first brackish, made so by occasional overflows from the Gulf, and then fresh for miles to the pine lands, but still not above the highest storm tides of the Gulf.

These marshes, excepting in Texas, were donated largely by the United States to the several States, ostensibly to secure their improvement, and titles to large tracts have since passed to railroad and other corporations, but there has been little attempt at reclamation in any of the States excepting Louisiana. The open grassy marshes, where firm enough, are used as winter stock ranges. In Texas such as are available for this use have been bought by stockmen, and are more valuable than upland. The southern part of the Texas coast is destitute of permanent fresh-water streams, and of no value, present or prospective, for agriculture or grazing.

In Louisiana large tracts (in one case 1,000,000 acres) have been purchased from the State to reclaim for rice and cane culture.

The account furnished by Mr. Watkins of operations in Southwest Louisiana is worthy of especial attention. Operations near to the delta of the Mississippi have to contend with the spring overflows of that river, which have proved an uncertain and troublesome element in all calculations. The statement of Mr. Allen, president of the Louisiana Land Reclamation Company, Mr. Thompson's letter, and others from that part of Louisiana, will be found of great interest.

Nothing has been done toward the reclamation of tide marshes in Mississippi, Alabama, or on the Gulf coast of Florida. They are used to some extent as stock ranges, but are for the most part unprofitable wastes. In Florida many of the marshes secure from the incursions of salt water are covered with valuable cypress.

The tidal action on the Gulf coast is small, and the elevation of the marshes insufficient to afford perfect drainage through tide-gates; hence

these must be supplemented by pumping machinery to be used when the rainfall is for many days in excess of evaporation or when a wind from the Gulf prevails. This must be a feature of all *thorough* reclamation on that coast.

Stock-raising must long continue to be, as it is now, a leading interest. At present 1,000 acres support from fifty to two hundred cattle, but the time is not far distant when more will be demanded of the land. The marshes that afford the best pasturage are flooded only by high storm tides, and would be protected by dikes 3 or 4 feet high, while the ditches excavated by steam-dredges in making such dikes would, with tide-gates, relieve the land of water to such a degree that some of the finer pasture grasses would flourish. How far this would increase the stock-bearing capacity of the land has not been proved, but, the land being of unlimited fertility, it is probable that with the water kept at least a foot below the surface each acre would feed an ox. An experiment in such partial reclamation would be watched with great interest.

The climate of the Gulf coast favors the culture of cotton, cane, and rice, which flourish nowhere better than on reclaimed lands, and their special fitness for winter and spring vegetables and certain semi-tropical fruits (which railroads are now preparing to carry to Northern and Western markets) is not disputed.

Altogether there are unmistakable indications that, whether by American or English capital, some of the latent wealth of these marshes will be made productive.

5. THE PACIFIC COAST.

Our western coast, from San Diego to the Strait of Fuca, covering sixteen degrees of latitude and nearly eight degrees of longitude, is for the greater part bold and rocky. Immense stretches of marsh, such as characterize the Atlantic and Gulf coasts, are not found along the Pacific.

From the Mexican boundary to the Golden Gate the coast is broken by no great river, bay, or inlet, and the marshes are almost without exception on salt water. It is an arid region. Away from the few permanent streams the best and almost the only dependence for fresh water is on artesian wells, which have not furnished very efficient aid in reclaiming salt marshes, and probably will not. Nevertheless, along this southwest coast line, which is 500 miles long without following minor indentations, there are marshes of considerable area at several places which may and will be reclaimed for cultivation. (See notes from Monterey County.)

From the Golden Gate northward to the mouth of the Columbia we have nearly 700 miles of coast similar in its formation to that below San Francisco—abrupt and direct, with few harbors, no great rivers, and small areas of tide marsh. But we pass from an arid to a moist climate.

The coasts of Northern California and Oregon are liberally supplied with living streams from the mountains. Artesian wells are no longer in demand, and reclamation is less a question of getting than excluding fresh water. But it is a new country comparatively, with little capital invested in farming and none worthy of mention in reclaiming marsh lands.

Between the mouth of the Columbia and the Strait of Fuca, on the coast of Washington Territory, are two large bays, around which and at other points are large bodies of tide marsh fit for profitable reclamation. These and the marshes of Puget Sound, which they resemble in all essential features, are sufficiently described in an abridgment of a paper prepared by Eldridge Morse, esq., for this report.

This cursory survey of the coast line takes no note of the three great tide-land regions of the Pacific. The least important of these in extent and development is the Lower Columbia. Enough has been done here to show the practicability of reclaiming these lands with profit, and greater interest is taken now than ever before in their improvement. Abstracts of correspondence from the counties of Oregon and Washington bordering the Lower Columbia are given elsewhere.

The Puget Sound region has no parallel. Remote as it is from the centers of population and capital, it has attracted little general attention, even since the completion of the Northern Pacific Railroad. While Eastern capitalists were speculating on the probabilities of marsh reclamation as a field for profitable investment near the large cities, where the reclaimed lands would be in demand for market gardens at high rates, a few venturesome settlers, tempted by the demand of the logging camps for hay and oats, went to work on the tide marshes (because there was no other available clear land), and in a rude way solved the problem of profitable reclamation for farming alone where marsh and dry land were alike free. Perhaps no other farm lands in the country have for a series of years yielded so large returns on the invested capital as the diked lands of Puget Sound. It has been thought advisable to devote considerable space to this remarkable region, and accordingly there will be found, in addition to the abstract of Mr. Morse's paper before referred to, several interesting letters from prominent owners of diked lands on the Sound.

Among the noticeable features of these lands and conditions affecting their reclamation are (1) their elevation above low water, thus securing outlet for thorough drainage, (2) the absence of very high storm tides, which necessitate costly dikes; (3) the general, almost universal, excellence of the soil, which, with a favoring climate, produces enormous crops; and (4) the general healthfulness of the country and absence of all malarial disease.

These and other characteristics of the Puget Sound marshes are considered in the several communications mentioned. It will be noticed that there, as elsewhere, reclamation is greatly retarded and made in-

secure by reason of imperfect and insufficient laws. Diking necessarily involves the interests of communities, and when the rights and duties of individuals are not clearly defined by just and equitable laws the general welfare must suffer.

The necessity for thorough drainage, in addition to the exclusion of tides and floods, has not heretofore been fully understood, but leading farmers are moving in that direction, and as a result harvesting crops of grain and hay which find no counterpart in upland farming.

Diking on the Sound has, with rare exceptions, been done by hand labor, directed by individual enterprise. Comprehensive systems of reclamation are wanting, and much expense and heavy losses have been incurred that with concerted action and good management would have been avoided; but with all drawbacks and imperfections the results actually accomplished are so remarkable as to fully justify the prominence given to reclamation on Puget Sound.

The remaining and in some respects the most important tide-marsh region of the Pacific, and, indeed, of our entire country, is within the Golden Gate. Conditions, methods, and results worthy of study will be found in (1) the preference given to the fresh-water lands of the delta over the salt marshes of the bays, (2) hydraulic mining and floods in the Sacramento and San Joaquin, (3) the employment of large capital and expensive machinery in making dikes and drains to a greater extent than elsewhere in any completed reclamations, and (4) the profits of grass and fruit farming on the reclaimed lands.

It will be observed that on the entire Pacific coast there is a liberal range of tidal action, which in some parts of Puget Sound reaches 20 feet. The marshes being generally at or near the level of ordinary high water, the importance of the range of tidal action (which determines the elevation of the marsh above low water, and consequently the facility and degree of automatic drainage) is obvious.

IV.—MANAGEMENT OF RECLAIMED LANDS

Marshes *thoroughly reclaimed*, as compared with the best uplands in their vicinity, are not at a disadvantage in the production of any crops of general adaptation excepting through their greater liability when remote from salt water to late and early frosts, a feature they share in common with all low land similarly situated. But marshes are often imperfectly drained, a condition of which grasses are, as a rule, more tolerant than grain crops. And this, to some extent, explains the preference given to grass. Aside from this, however, and on the best-drained tide lands, grass is the leading crop, and presumably so because it is the most profitable. Such is the case on the banked meadows of New Jersey, Pennsylvania, and Delaware, and on the Pacific coast the tendency is in the same direction. Where grass is preferred the sod is only broken when it fails, and after cultivation one year or more in other crops the land is reseeded with grass.

It is not customary to apply barn-yard or other manures to diked lands, though there is abundant evidence that they would respond liberally to such treatment. The wisdom of bestowing all manure on the poorer and often barren upland is not entirely apparent. Indeed, the practice is not defended by many intelligent and prosperous men who still adhere to it. They admit that a concentration of resources and efforts on the meadows would give much better results. But the meadows bear ill treatment patiently, and so they are put off with an occasional dressing of lime, or, if they fail, are turned out to be renewed by deposits from the tides.

After thorough reclamation, which involves strong dikes and well-guarded sluices (or efficient lifting machinery), only a moderate degree of watchfulness is required. Muskrats and other burrowing animals give little trouble in dredge-built dikes or around sluices that have not been slighted in construction. But drainage is absolutely indispensable, and ditches have a tendency to become silted or obstructed by vegetation. So small is the margin for drainage in most tide lands that underdrains are impracticable, and the condition of the ditches should always be perfect. Nearly all failures of crops on good tide lands result from imperfect drainage; hence the importance of giving attention to this matter.

Rice, under water culture, differs in its requirements from all other crops, and its production is the object of the largest reclamation enter-

prises yet undertaken. The correspondence from the old rice region of the Atlantic States and from Louisiana will be found of interest in this connection.

With all the imperfections of tide-land farming as it has been practiced, results are presented indicating possibilities (which under improved methods are being realized) beyond the capabilities of the best uplands. To all the advantages of the latter the best diked lands add entire exemption from drought, which, through hindering the preparation of the land and shrinkage and loss of crops, is an incalculable evil.

V.—LEGISLATION.

Laws, both State and national, affecting reclamation are exceedingly defective, with the general result of discouraging rather than fostering improvement, and in some cases they work manifest injustice.

It is not right that a man or a number of men owning marsh land should, by refusing to improve or sell, be able to prevent improvement or, without cost, share its benefits when made by others. Nor is it right that a man, being in a minority, should be forced into an association with others involving expense which his judgment does not approve, with only the alternative of selling for such price as he can get, practically forfeiting his land in part if he refuses. Yet such results follow deficient and unjust drainage laws. The letter of Mr. Calhoun from Washington Territory, and sections of the statutes of Nova Scotia and New Brunswick quoted in Mr. Boardman's paper, will be read with much interest in this connection. It will be noticed that the principle so earnestly contended for by Mr. Calhoun, viz, assessment according to benefit, is distinctly embodied in the laws referred to.

Protection of private rights and the promotion of the public welfare in this matter require the earnest attention of all legislatures having jurisdiction. First, riparian rights should be, as in many cases they are not, distinctly defined. Then, the relations of reclamation to navigation should be thoroughly investigated by a competent commission, and all private rights inimical to greater commercial or other public interests should be extinguished at the public cost. Following this, provision should be made for the condemnation and improvement of such marshes as are public nuisances in cases where the owners fail to make such improvement. These reclamations could be made by and for the benefit of the State, or the marshes might be sold with improvement stipulations. The rôle of dog in the manger would thus become so difficult and unprofitable that few would care to continue or undertake it, and owners would in most cases agree with their neighbors to make desirable improvements, or, if they did not wish to join in the reclamation, would sell at fair prices, and thus excellent results would be accomplished with little direct interference of the law.

The large donations by the General Government to the States, of swamp and overflowed lands, however beneficent in design, have not resulted and are not likely to result in the improvement of these lands to any such extent as was contemplated. The State of Louisiana has,

however, sold large tracts of tide lands at nominal prices, subject to improvement stipulations, and there is a fair prospect that the taxable wealth of the State will be materially increased in consequence.

Lastly, surveys should be made of all public marsh lands, national and State, to determine their areas, character, and fitness for reclamation. It is not sound policy to give away or sell at nominal prices large areas of the public domain of which little or nothing is generally known.

VI.—AREAS, BY THE COAST SURVEY.

The most persistent and careful efforts have failed to get approximations to tide-marsh areas which could be presented with a good degree of confidence. A comparison of estimates one with another, and with results ascertained by actual surveys, shows the widest variation and such general untrustworthiness that only those known to have been made by competent and careful persons have been considered.

The unreliability of the estimates is due, first, to a lack of skill in estimating areas, and, second, to indefinite ideas of the thing to be estimated. When one man writes that a given township contains about 100 acres of tide marsh, and another puts the area at 10,000 acres, they are evidently thinking of different things; and the most careful definition of terms in letters of inquiry has been of no avail. Such difficulties were not limited to estimates of areas; they were inseparable from the entire investigation.

In this emergency, and for the purposes stated, the following letter was addressed to the Superintendent of the Coast Survey:

DEPARTMENT OF AGRICULTURE, *May* 17, 1884.

DEAR SIR: From the United States Coast Survey Report, 1869, Appendix No. 5, on the reclamation of tide lands and its relations to navigation, by Henry Mitchell, chief in physical hydrography, I quote:

"The period, however, has arrived when the seaboard of our Northern States has become so densely populated that projects of reclamation are becoming popular and promise favorable investments for capital. The topographical sheets of our Coast Survey, which reach the public only as printed maps, upon scales so reduced that many of the details and most of the original spirit are lost, furnish us with an amount of information relative to the extent and character of the tide marshes along our shores scarcely appreciated by those outside of our service. These surveys in the manuscript, as they reach us from the plane-table, furnish not only the measures of reclaimable marshes, but exhibit the configuration of the surrounding country so boldly, and at the same time so minutely, that one can scarcely cast his eyes over one of these sheets without superinducing upon it tempting schemes of conquest."

During the last fifteen years, and especially very recently, the subject of reclamation has attracted wider attention than ever before in this country, and it has been thought advisable to prepare a report on tide lands from an agricultural standpoint. With this in view I shall be under great obligation for such information as your office can furnish in regard to the area, location, character, elevation above low water, depth of submergence by spring tides and highest storm tides, exposure to surf, and other important conditions of these lands in the different sections of our coasts. If,

as I suppose, such description in detail would be very voluminous, will it not be practicable to treat the marshes in sections, as by States, or bordering a designated bay, river, &c., or at least in a general way by classes?

In addition to this I should be highly favored in receiving any light on the relations of reclamation to navigation of which your office has come into possession since the date of Professor Mitchell's discussion above mentioned.

I should have much pleasure in embodying in the report a paper covering the points indicated, from Professor Mitchell, or any gentleman of your staff to whom you may refer this request.

Very respectfully,

E. A. CARMAN,
Acting Commissioner.

Prof. J. E. HILGARD,
United States Coast and Geodetic Survey, Washington, D. C.

A reply was received showing the great interest felt by the Superintendent on the subject of tide-land reclamation, and promising such aid as his office could furnish.

It is greatly to be regretted that it was not found practicable to prepare the desired paper on the relations of reclamation to navigation.

The table of areas, &c., furnished, of which a recapitulation is here given, refer only to Maine and the District of Columbia in addition to the original thirteen States. The detail tables, being voluminous, are filed and accessible to persons interested in particular localities. It will be observed that the items, being made up from different sources, do not agree in common standards of definition and classification. For instance, in Pennsylvania and in the District of Columbia, where the tide water is fresh, the marshes are technically designated as "salt marsh" in one case and "swamp land" in the other. In the first the small area is best accounted for on the supposition that diked lands are not counted, though they are included in the figures given for New Jersey, while in the other case the name "swamp land" is doubtless used to designate some particular grade or kind of tide marsh, as the whole area of land in the District commonly known as tide marsh greatly exceeds the amount stated.

It was thought desirable in a popular report to add such explanations of scientific terms and classifications as would obviate any possible misunderstanding, and accordingly the matter was brought to the notice of the Coast Survey Office, but no remedy was found.

Col. C. O. Boutelle, assistant, Coast and Geodetic Survey, in charge of office, in presenting the tables, writes:

I have caused to be made a careful and laborious series of measurements of the amounts of salt and fresh marsh land upon the Atlantic seaboard.

While I do not present the accompanying table of results as precisely accurate, it is safe to state that it is the result of a careful investigation of the subject and is more precise than any previous information I have been able to obtain.

RECAPITULATION.

Section.	Authority.	Swamp land.	Salt marsh.
		Square miles.	*Square miles.*
District of Columbia	U. S. C. and G. Charts of Potomac River	.7528	
Maryland	U. S C. and G. Coast, River, and Harbor Charts and Hydrographic Sheets.	1.8085	290.1235
Do	Martinet's Atlas of Maryland	8.56	
Virginia	U. S. C. and G. Coast, River, and Harbor Charts	9.0453	312.9916
Do	U. S. C. and G. Military Map of Virginia	195.4830	
North Carolina	U. S. C. and G. Coast, River, and Harbor Charts	111.0363	182.9007
Do	U. S C. and G. Military Map of North Carolina	4,101.59	
South Carolina	U. S. C. and G. Coast, River, and Harbor Charts	1.2278	491.475
Do	U. S. C. and G. Military Map of South Carolina	3,399.09	147.88
Georgia	U. S. C. and G. Coast, River, and Harbor Charts	9.6769	445.8642
Do	U. S. C. and G. Military Map of Georgia	1.171.33	
Maine	U. S. C. and G. Charts and Topographical Sheets and County Maps.	3.0078	27.3835
New Hampshire	U. S. C. and G. Charts		8.2661
Massachusetts	U. S. C. and G. Charts and Walling's and Gray's Official Topographical Atlas.	5.1847	87.5222
Rhode Island	U. S. C. and G. Charts	5.5872	7.1147
Connecticut	U. S. C. and G. Sheets, Reduced Drawings of Topographical Sheets, and Bache's Atlas of New Haven	1.6695	34.7873
New York	U. S. C. and G. Charts and Reduced Drawings	1.7277	109.6662
Do	Lloyd's Map of the Hudson River	.9	
New Jersey	Beer's State Atlas (the quantities were tabulated there).	49.61	461.62
Pennsylvania	U. S. C. and G. Charts		3.5751
Delaware	U. S. C. and G. Charts and French and Skinner's Atlas of Kent County.		94.6912
Do	Rea's and Price's Atlas of New Castle County		6.15
Do	Martinet's Atlas of Maryland	29 08	

VII.—THE TIDAL LANDS AND DIKED MARSHES OF NOVA SCOTIA AND NEW BRUNSWICK.

By Samuel L. Boardman.

ACKNOWLEDGMENTS.

I desire to make acknowledgments to the following-named persons, to whom I am greatly indebted for kindness, assistance, and information in preparing the accompanying report:

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NOVA SCOTIA AND NEW BRUNSWICK.

A.—Location and extent.

I commenced my studies and investigations of the tidal lands and diked marshes of Nova Scotia at and near Annapolis. This little village is situated on the Annapolis Basin, just at the entrance of Annapolis River into the bay, and is one of the oldest settled places in the province. It was named Port Royal by the Baron de Pontrincourt. As early as 1606 the colony of Frenchmen who commenced a settlement here began improvements upon the land, one of the first operations being the building of dikes; and all over the province, wherever there are diked lands, the dikes date back to the first settlement of the several localities by the French. The early settlers of old Acadia came chiefly from the lowlands of the Loire, in France, where were extensive systems of diked marshes along the Loire, Forez, and Rhone. The broad plains or marshes on the Forez, supposed to be the beds of ancient lakes, were early reclaimed by dikes, canals, and drains. The French set-

tlers of Acadia brought over with them to their new homes the art of making dikes, "and we have not in all subsequent operations of the kind," observed the learned Judge Morse, of Amherst, Nova Scotia, to me, "advanced a step beyond the French farmers of 1606." Indeed, it is asserted that when the English settlers attempted to repair dikes that had been destroyed by the French in 1710, they had to send for Frenchmen to do the work, as the English could not build or repair a dike that would stop the movement of the sea.

Annapolis is situated on the eastern shore of the Annapolis Basin, and opposite is the little village of Granville, the town of Granville extending for several miles along the basin and river. On both sides of the basin below the towns, and on the river Annapolis and creeks entering into it above the towns, are tracts of diked lands, but they are generally narrow and of small extent compared with those in Kings, Colchester, and Cumberland Counties, Nova Scotia, and Westmoreland County, New Brunswick, at the head of the Bay of Fundy. In the townships of Annapolis, Granville, and Wilmot the dikes are all named, and vary in size from 50 to 2,000 acres. And here I may as well explain or define the terms "dike" and "marsh" as used everywhere in the province. "Dike" is employed to describe a diked or improved meadow; "marsh" refers to land that has not been improved by diking. "He is on the dike" does not mean that he is on the embankment, but is on the meadow that has been diked. Marsh is salt land over which the sea flows at will.* The names of dikes are those used by the old French residents, or they take the name of the owner, or are given some modern name. Among those in the vicinity of Annapolis are the following: Winchester, Dougall, Marshall, Rosette, Pea Round, Horseshoe, Tupperville, Whitman's, Messenger, Bellisle, and Carleton. Many of the dikes here are very old, and are not built in as serviceable a manner as are those in other parts of the province. About here are also some dikes that are down or "gone out." This last is a term applied to land which has once been reclaimed, but as the dike or embankment has been broken down, the sea has come in and the land has "gone out" with the tide.

In the vicinity of Annapolis and Granville the marshes are in general about 20 feet above low water, and the common rise of the tides is 25 to 27 feet. In most places the soil is a red clay, a fine alluvial deposit, but often in and around the creeks it is quaggy, peaty, and poor, a dark-colored soil of little value. The surface soil on the creek banks is from 3 to 7 feet deep, but inside the dike toward the upland it grows shoaler. Sometimes at a depth of 3 feet there is a subsoil of blue clay, often a quaggy subsoil. In many places like the last named remains

* These terms refer to Nova Scotia. By the statutes of New Brunswick, chapter 115, section 62, "the words 'marsh' or 'marsh lands' shall, as used in said act, extend to and mean diked, marsh, and low lands, bogs, and meadows."—(*Consolidated Statutes of New Brunswick*, 1877, page 935.)

of old stumps, logs, and forest trees have been found at a depth of from 2 to 3 feet below the surface. The vegetation of the unimproved marshes is a short salt grass, mezoit grass (a short, hard grass), bull-tongue, goose-tongue, sedge, &c. These are local names applied to the natural growth of the salt marshes, and in general these grasses possess very little feeding value. Salt grass—this is the universal testimony of farmers—makes a very poor hay. In winter cattle like a feed of it occasionally, say once or twice a week, but it is almost worthless as a "steady diet," and the testimony of the cattle, as well as the farmers, is against it. Dike that is built on soft land will settle 2 feet in from four to five years, and then it must be "topped" out; and land that is reclaimed and drained by diking also becomes from 2 to 3 feet lower than the land outside in the course of a few years; at least this was the statement made to me by several gentlemen. But the land within the dike does not settle as much, I think, as the land outside fills up by the deposit of sediment which the tide leaves, which would give the appearance that the land inside the dike was being depressed. But it is doubtless true that as the water is taken out of a salt marsh, and drains provided for its improvement, the land does become drier, firmer, and no doubt somewhat lower. I was informed that in the vicinity of Annapolis and Granville there were probably not more than two or three hundred acres of unimproved or salt marsh. Diked land of good quality is worth here $150 to $200 per acre, and in some instances even $400. Such land will yield from 2½ to 4 tons of the best timothy and clover, per acre. Upland in the same vicinity is worth from $40 to $50 per acre.

One of the most extensive dikes in Annapolis County is the Queen Anne Dike, in Middle Granville, just below Stormy Beach, which I visited, in company with Mr. William Winchester, and inspected with great interest and care. It was built in 1877. The dike is 400 rods in length and incloses about 500 acres. It was at the date of my visit, July 14, bearing a handsome growth of timothy and clover that was good for from 3 to 4 tons of hay to the acre. There had formerly been an old dike here, but it had not been improved since the time the French cut it and let it "go out," when the English gained possession of the country, in 1710. At that time much of the land was in wheat, and Mr. Winchester, as well as Mr. Dimock Whitman, who had charge of the dike when building, informed me that at a depth of from 2 to 3 feet below the surface wheat hulls were dug up as sound and bright as when left growing there a hundred and sixty years ago, having been buried by the sediment deposited by the tides. In Annapolis and Granville the individual ownerships in dikes embrace from 7 to 25 acres. Dikes or small area extend along the Annapolis River up some 16 miles from its mouth. All along the valley of the Annapolis the diked lands are among the most valuable of the improved lands, and are wholly devoted to grass and grain. Between the river and the North Mountains is a

generally level valley of from one-half mile to 2 miles in width. The soil is a deep, rich, fertile loam, of a reddish color, called here a clay loam. The soil is productive, and great crops of apples, potatoes, and oats are grown.

In Kings County, which faces the Minas Channel and Basin of Minas, there are between five and six thousand acres of diked meadow, the largest bodies of which are the Wellington Dike, in Canning, and the Grand Pré Dike, in Horton. A correct list of the dikes in this county, with the number of acres in each, is as follows:

Name of dike.	Extent.	Name of dike.	Extent.
	Acres.		*Acres.*
Pereaux	65	Town River	300
Greenwich	90	Wickwire	550
Gaspereaux River (about)	100	Grand Pré	1,944
Town Plot	150	Wellington	2,200
Dead	170		
Habitant	268	Total	5,837

These dikes are all situated on the Basin of Minas and rivers and creeks running into it. The Grand Pré Dike is one of the oldest in Kings County and one of the best in the province. The old French had dikes here on the first occupation of the country, and there are now to be seen all over the Grand Pré remains of old dikes within those now doing duty in keeping back the tide. These have been plowed down and leveled off in places, but it is not a difficult matter to trace them. The French had no extended system of dikes at the first, but built around and inclosed land by the courses of the rivers and creeks, following up one side to fresh water, or to that point to which the tide flowed back, and down on the other. This made their dikes very irregular and expensive—had expense been taken into account. And these old dikes, or remains of them, are easily traced on the Grand Pré, following the crooked courses of the marsh creeks, now inclosed and forming good land. It was not till 1746 that an *aboiteau* was built, under direction of Father Joseph de la Loutre, on the Cumberland marshes.* The French seem to have had an idea that the upland was quite valueless for purposes of tillage. About the Grand Pré their villages were built on the points of upland extending out toward the marshes; they cleared little spots about these villages, but all the remainder of the high land was in forest.

About the Grand Pré the common tides rise to the height of 45 feet, and storm tides usually rise 10 or 11 feet higher. The general elevation of the marshes above low water is not far from 55 feet. This body of dike comprises very nearly 2,000 acres, and is about 2 miles by 3 in extent. The soil is a fine alluvial deposit, reddish brown in color, and has a depth of from 15 to 20 feet. Indeed, I am not sure that a "bottom," so to speak, or subsoil of any other character has ever been

* Archives of Nova Scotia, by Thomas B. Aikens, Halifax, 1869, page 178.

reached. Mr. William Stewart, who has been a commissioner of dikes and sewers for thirty-six years, informs me that the depth of this rich Grand Pré soil is practically unknown. There are but very few small pieces of unimproved marsh in the vicinity of Grand Pré, but where it is found the vegetation is a fine salt grass or sedge. The only advantage it possesses as feed, as Mr. Stewart informs me, is "that it makes the cleanest manure, *i. e.*, free from weeds, of any they can have." The diked land here is worth from $150 to $300 per acre, and some of it is worth $400, while upland is worth from $30 to $60.

The poorest land generally on the dike is that which is the highest, the soil being a blue, peaty, oozing clay. The Grand Pré Dike is guarded from the sea by Long Island, some 2½ miles long, which lies across its front in the Basin of Minas. The tide in coming round the island on both sides meets in the center. The waters meeting containing a less amount of sediment than the waters following, leave little richness to the soil, while the richer deposits are near those points where the creeks are. On these high points the salt never gets fairly out of the land, for in dry seasons a white crust will form on the surface which is "as salt as the ocean." On the poorer lands I noticed that white-weed or ox-eye daisy (*Leucanthemum vulgare*), and brown-top or brown-bent (*Agrostis canina*) had come in, as on our poor upland fields. These high spots have sometimes been treated with lime, good results following the application.

There are on the Grand Pré Dike three public roads, for when one stops to consider the size of the dike (2 miles by 3) it will be readily seen that roads over such an extent of country are necessary as a matter of public convenience. One of these is a county road and two are dike roads, but all are known as "pent" or inclosed roads, which the public may use, subject to a penalty for leaving the gates open.

On the Grand Pré Dike, and also on dikes in Truro and Amherst, I found growing considerable quantities of what was called broad-leaf—a grass that is much esteemed, and which I am quite sure is *Spartina cynosuroides.**

James Laird, esq., of Horton, clerk to the board of commissioners for the Grand Pré, showed me a copy of an old map of the date of 1760, which he had himself made from one in the provincial archives, which delineated the situation of individual lots on the dike, their number, and the names of persons owning them at that date. It is by this map that sales and changes of lots are made and recorded. Bounds of individual lots are indicated by boundary ditches, although monuments are employed for indicating bounds of large bodies of dike. Many of these lots are

* What is now known as *Spartina cynosuroides* is the *Dactylis cynosuroides* of Linnæus (Species Plantarum, p. 104), but Linnæus included a very different plant, the *Spartum Essexiense* of Ray, which is now known as *Spartina stricta*, a hard, tough, rigid grass that grows in England and in salt marshes of Pennsylvania.—Prof. GEORGE LAWSON, *Dalhousie College, Halifax, Nova Scotia.*

owned by non-resident proprietors, and much of the grass is sold standing. When cut, some is frequently stacked, but generally it is at once hauled to the barn. The dike is owned in lots of from 10 to 100 acres.

Crossing the river Avon at Windsor town, we enter the county of Hants. The Avon is a beautiful river, and the valley along its banks on either side is delightful. Dikes extend up its waters for some 7 miles from its mouth, and there are also dikes on the creeks making into it. On the Falmouth side of the river there are about 1,000 acres of dike, and on the Windsor side fully 2,000. The dikes in the town of Windsor are the St. Croix, Winckmouth, and Kennectcook. The tides at this point, at their common run, are 30 feet, monthly or high tides reaching 43 feet. Generally the separate lots of dike land owned by individuals are from 5 to 60 acres, seldom reaching 100. The soil is a fine alluvial deposit of from 25 to 30 feet in depth, with no change in character. In small sections there is a black, spongy soil which is seldom over 2 feet deep. The vegetation on the unreclaimed marsh here is flat-grass, broad-leaf, black-grass, and sedge. The price of dike lands varies from $40 to $200 per acre, of upland from $25 to $40.

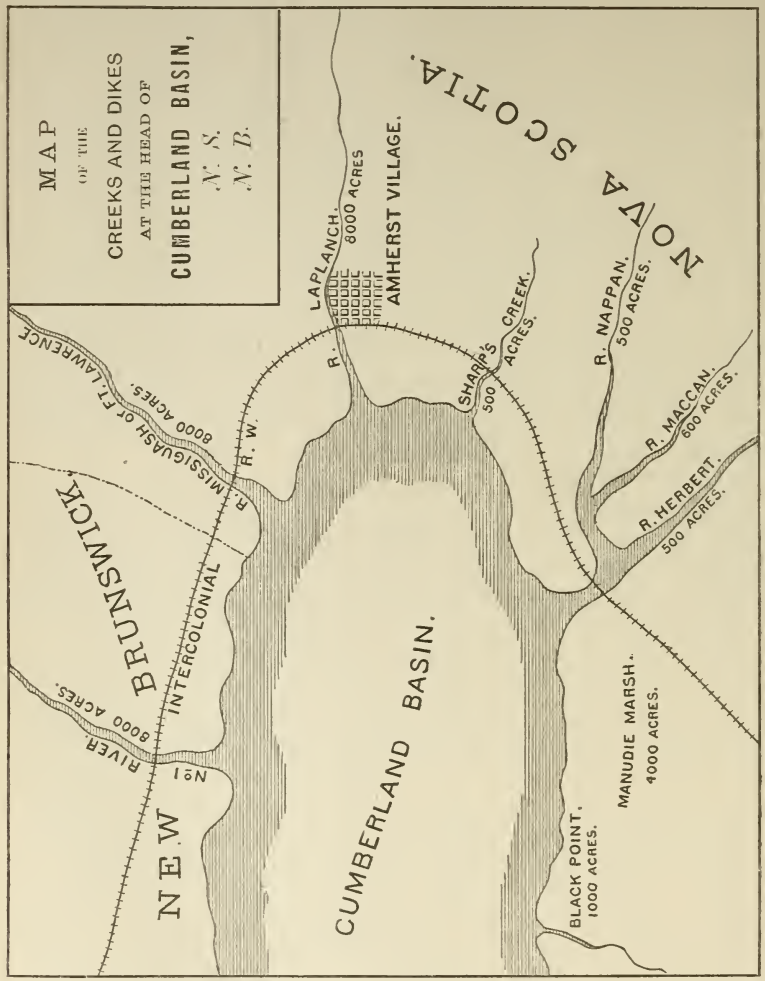
Some years since a company of English capitalists undertook the reclamation of the island of Cole Harbor, off Dartmouth, near Halifax. This island consisted of about 1,500 acres of land, the soil being a coarse white sand, with marine materials and shell mud. Vast sums of money were put out in the works, which were under the charge of an English engineer. An expensive system of drainage was laid out and crib-work constructed to hold the sediment back from tide water and to keep the water from going out too rapidly. The design of the company was to grow grass, and also all kinds of field and garden crops for the Halifax market. From all I could learn of this enterprise, it being very inconvenient and expensive for me to visit it personally, it is believed to have been far more expensive than was at first planned for, and to have hardly met the expectations of the company as an investment. Mr. Bisset is the manager for the company, but the facts concerning it were given me by Prof. George Lawson, of Halifax, secretary of the central board of agriculture for Nova Scotia.

Truro is situated at the head of Cobequid Bay, an arm of the Basin of Minas, and the most eastern point to which the waters of the Bay of Fundy extend. I was charmed by the location of the place. The land all about the town is level, the streets are wide and regularly laid out, the buildings good, and everything indicates a prosperous, intelligent community. It is the shiretown of Colchester County. Opposite to it is the town of Onslow, and to the westward, or across the head of Cobequid Bay, the town of Londonderry. The Salmon River comes into the bay at Truro, at Onslow the river Churanois, and at Londonderry the Folly and Great Bass Rivers. The very highest storm tides at Truro do not rise above 10 feet, the common tides being from 4 to 6 feet. It will be seen from the comparative low run of tides here that they do not enter

he rivers to any very great extent; consequently the amount of dike on the above-named rivers is limited. About here the dikes are the Salmon River, Lower Truro, Onslow, Lower Onslow, Marston, and Clifton, while on the north shore of Cobequid Bay are Londonderry Little Dike, Londonderry Great Dike, and Folly River. At Truro the dikes extend to about 1,000 acres, and at Londonderry and Onslow to from 5,000 to 7,000 acres. The soil is a deep, fine, loamy clay, on a mud bottom, the color of the loam being the common or prevailing red. The rivers are diked up as far as the tide runs, from 3 to 4 miles; and it is the general practice of farmers to keep the dike in sward as long as it can possibly be done, not plowing oftener that is absolutely necessary. The better quality of the grass (which, as elsewhere, consists of timothy and clover) grows near the dike; back from the dike toward the upland it is disposed to run out. The farmers about Truro have a practice which I did not observe much in other parts of the province, viz., the use of river mud as a top dressing for fresh lands. This salt mud is hauled in the winter and spread immediately on land plowed in the fall. Many farmers work all winter at this business, having long, low sleds fitted up for the purpose. The farther down the bay the mud is obtained the better the quality. It is applied at the rate of from 30 to 100 cords to the acre, with the best results. Farmers on the north shore of the bay are also using it to a considerable extent. For many of the above facts I am under obligations to Mr. William Sutherland, one of the sewer commissioners for the Truro dikes.

Going west from Truro, Amherst is the last town in Nova Scotia, the Missiquash River forming the boundary between that town and Sackville, in New Brunswick. The waters of Cumberland Basin, at the head of Chignecto Bay, sweep in opposite Amherst and Aulac, the basin and bay above named forming one of the great arms of the Bay of Fundy. The dikes here are on a grand scale. In order to give an idea of their extent the accompanying sketch map is introduced. Commencing to the westward on the southern reach of Cumberland Basin, there is a dike at Black Point, near the Westcock Marsh, which comprises about 1,000 acres. Lying between this and the river Herbert is the Manudie Dike, of 4,000 acres. Upon the river Herbert are some 500 acres of dike. Sweeping round toward Amherst we come to the Maccan River, with 600 acres of dike, and next the Nappan River, with 500 acres. These two rivers unite and flow into the river Herbert a mile or so from its confluence with the basin. At Amherst Point, below the village of Amherst, is a dike of over 1,700 acres. At Sharp's Creek there are 500 acres of dike. On the La Planche, north side of Amherst village, are 8,000 acres of dike. Next we come to the Fort Lawrence or Missiquash Dike, which comprises 9,000 acres. I also include in the body of dike properly belonging to this formation (although across the boundary in New Brunswick) the No. 1 River or Westmoreland Point Dike, comprising 4,000 acres. These compose the Amherst body of dike, and I have the

figures of extent from Capt. Richard Lawrison, now and for many years past one of the commissioners of sewers for this dike. The total aggregates 25,200 acres, which is probably below rather than above the actual extent. The rivers and creeks on which these dikes are located flow back from the basin from 2 to 7 and some as many as 12 and 18 miles. The common tides at Amherst rise to a height of 30 feet, storm tides reaching 10 feet higher, or 40 feet. The general formation of



the dike soil is a fine, rich, deep, red-colored sedimentary alluvium. In many places, as near the wider parts of the creeks and toward the basin, it is practically "bottomless." Higher up the creeks, where the influence of fresh water is greater, the soil is thinner, having a depth of some 2 to 3 feet, on a subsoil of bluish, peaty clay. Here broad-leaf and marsh-grass grow naturally.

The diked lands of the Amherst body stretch away almost as far as the eye can extend, and in passing over it by rail (the Intercolonial Railway sweeps clear across it, around the head of Cumberland Basin) the sight is not unlike that of a Western prairie, but for the villages, the high land back from the creeks, and the numberless barns to store the hay from harvest time until it is hauled to the home farms on the approach of the first snows. As many of the dike lots are owned by farmers living several miles away, it would be simply impossible for them to haul the hay home during the haying season, and there is great loss from stacking, which was formerly the custom. On these dikes the best of the English grasses flourish, timothy, clover, and couch (*Triticum repens*) being the chief, and the general yield is 2½ to 3 and sometimes more than 3 tons to the acre. While couch is regarded as a weed in upland fields, and is never tolerated, it is esteemed as a grass, making the best of hay.

Having mentioned the sizes of these several dikes, it will give a good idea of their extent in another way to say that a person can start upon the dike (embankment) at Aulac and travel for 15 miles without stepping off. This relates to old dikes that are in operation now; and while the marsh land along the rivers for from 7 to 10 miles has been brought under improvement, the work is still being carried forward at points as far back from the basin as 15 miles, and this, too, by companies owning large tracts of lands now undergoing transformation from worthless bog to valuable grass land producing the best English hay. A brief reference to one of these great improvements may be made here.

At the mouth of the La Planche River there has existed for many years an *aboiteau* which has confined the sea and redeemed the land along its banks for some 2 miles. Back from this point, extending northeastward for some 15 miles, is a large tract of low land and shallow, boggy ponds, around which are thousands of acres of worthless water-soaked land, the same being so low that the waters of the sea would flow back but for the *aboiteau*. Along these ponds Captain Richard Lawrison, Judge Morse, and Hon. Hiram Black (father of the present Hon. Hiram Black, one of the commissioners for the Amherst body of dike) were wont to engage in the sport of shooting ducks. On one of these outings, as the gentlemen named were in a boat on a pond *over* Judge Black's land, Captain Lawrison said to him, "Judge, you ought to have a cow pasture here, where the water is 4 feet deep." Then Captain Lawrison explained to his companions his idea of draining and improving all the land about the headwaters of the La Planche River, extinguishing the lakes, and making good land of the worthless bogs. He would do it, he said, by the action of the sea alone, provided he could have the *aboiteau* at the mouth of the La Planche removed. The gentlemen became interested in the plan, Judge Black wrote articles in the papers advocating it, a company was formed to carry on

the work, and through the combined influence of these agencies an act of the provincial assembly was secured granting them power to remove the *aboiteau* across La Planche River, and to borrow money with which to carry on the work of "reclaiming, diking, and draining land," which act was passed February 27, 1882. The proprietors of the land, having secured the legislation needed, went to work at once. New dikes were built where needed to confine the sea, the *aboiteau* was "let out," and a canal to receive the sea by a short cut and avoid damage to land was dug. The tide enters the canal after passing where the old *aboiteau* was placed, and the water, charged with a fine deposit, goes up the river, the creeks, and the lakes for miles. On the high tide, when the water is still, the sediment drops to the bottom, and the peaty, boggy, moss-covered, worthless land is coated with a fine alluvium from the sea. This work of reclaiming the poor land about the headwaters of the La Planche River is now being carried forward rapidly. Judge Morse, of Amherst, has, I believe, some 16,000 acres of land of this character to be reclaimed. In this tract are several ponds or lakes of from 10 to 20 or more acres each, which are being filled by the tide deposits, and will in the course of a few years be converted into solid, cultivated fields. A similar enterprise is being carried on in Clifton, Colchester County, and work upon it has been in progress for the past ten or fifteen years. I was informed by gentlemen of good judgment that this wet, boggy land, not worth 5 cents per acre before its improvement, was taken in hand, and when filled and diked is worth $150 or $200 per acre.

At the mouth of the Aulac River is the Etter *Aboiteau*, the largest ever constructed in the provinces. It was built by Mr. Isaac Lawrison in 1862–'63, and cost £5,500, or $27,500. This immense *aboiteau* has a width at the base of 80 feet, a height of 45 feet, and is 40 feet wide on the top surface. Its sluice-way has four openings, each 4 feet square. The tracks of the Intercolonial Railway now cross the Aulac River over this *aboiteau*. This and a smaller one across the Sackville River may be regarded as the gate-ways to the celebrated Tantramar Dike, in Westmoreland County, New Brunswick, comprising 100,000 acres, the largest body of diked land in either province. This dike is about 4 miles wide by 9 miles long, and is traversed by the Tantramar River and many smaller creeks, beside the Aulac and Sackville Rivers just mentioned. The soil of this dike is chiefly a very fine silicious matter, deposited as marine alluvium, and is known as *red* marsh, in distinction from the *blue* marsh, which is of a poorer quality and very shoal. Mr. Isaac Lawrison, who has been one of the dike commissioners for many years and has made a life-long study of their physical features, classifies the diked lands as follows: No. 1 he describes as the best quicksand marsh, having a depth of from 5 to 30 feet; No. 2 has a soil of similar character, from 2½ to 3 feet deep; No. 3 is a shoal, poor blue clay, about 18 inches deep. The first grows in great luxuriance the best English grasses; the

second grows a finer, poorer quality of grass, brown-top, &c.; and the third yields a coarse broad-leaf.

I made at all points visited (described in the preceding pages) careful studies of the soil of the dikes and the tide waters making along the same. The soil has generally been described as a very deep, fine, marine alluvium of a dull red color; "red clay" it is called in some localities, "red quicksand" in others. All around the headwaters of the Bay of Fundy, in all its arms and basins and up the rivers and creeks making into the bay, its waters are loaded with this fine marine alluvium, brought in by every tide. There are exhaustless deposits of plaster all about the Bay of Fundy, with red sandstone, that gives the muddy water, and the dike soil its color. The waters of the high tides also contain and deposit diatomaceous matter, minute shells, and microscopic animals, which yield ammonia and carbonate and phosphate of lime. The water of the Bay of Fundy is filled with this fine, rich matter, which gives the diked land its value, for the soil has been formed by deposits from the tides. In this respect the waters of the Bay of Fundy differ greatly from the tide waters of the Eastern Maine coast. There the rock formations are chiefly granite and the soil granitic. The tide waters along their coasts are generally blue and clear, containing but little that conduces to fertility.

The great extent of the Tantramar Dike renders it inexpedient to have it administered as a single body. In consequence it is divided into twelve bodies, among the largest being the following: Sackville, Westmoreland Parish, Dorchester, and Memnocook. These bodies vary in size from 1,500 to 3,000 acres. The meaning of the term "body" is explained in the division relating to the legal administration of diked lands.

An enterprise of great magnitude is now being carried on in that part of Westmoreland County which lies north and east from Sackville and beyond the region of the improved Tantramar Dike. This is the reclamation of an immense territory of now unproductive and worthless land by the same agencies as have been employed at Amherst, in Nova Scotia. This tract of land lies along the route of the New Brunswick and Prince Edward Railroad—a new line being built to connect Prince Edward Island by a short route with the province of New Brunswick. This line runs from Sackville to Cape Jourimain, on the Northumberland Strait, the nearest point of land to the island. The Dominion Government has built a pier at the cape, and a company is now engaged in constructing the road, which will eventually pass into the hands of the Government. The improvement of this large body of land is in the hands of proprietors, who are pushing the work with great rapidity. Dikes are built, canals made to transmit the tide water upon land to be improved, and the same methods put in operation as have proved so successful in other places. The salt water sinks to the bottom of the

canals and creeks, and as these connect with large fresh-water lakes and ponds, the fresh water rises and is carried off by the out-going tide. The sediment which the flood tide contains in abundance is deposited upon this worthless, boggy, moss-grown land, which it utterly eats up and drowns in the course of a few years. In like manner the fresh-water lakes are filled up with sediment and converted into good land, barring a channel for the current. Land not worth "five cents an acre," as the terms are, is thus in a few years made into splendid alluvial interval, yielding the best of English grasses and worth $150 to $200 per acre. Mr. Thomas Esterbrook, of Sackville, is interested in the reclamation of about 1,000 acres of worthless bog, knee-deep in water, moss, and peaty turf. In 1883 he made a trial with a piece of this land to ascertain how fast it was being subdued. The tides from June 1, 1883, to November 30, 1883—the tides for the month of August having been shut out—a period of five months, deposited 23 inches of the finest and best soil upon the land in question. The salt water kills out the native grasses on fresh marsh, and, as the land fills in, English grasses come in naturally.

The Petitcodiac River forms the boundary between Albert and Westmoreland Counties. Along this river are bodies of marsh (diked) of considerable extent, especially in Hillsborough, which is situated on the bend between the river and the waters of the western part of Chignecto Bay. Also about Moncton are dikes of small extent.

B.—Construction and maintenance of the dikes.

With the exception of the Queen Anne Dike at Middle Granville, the dikes on the Lower Annapolis are not very important as works of engineering. Most of them are old, and show evidence of much repairing by methods which probably serve their purpose well for the locality, but would be discarded at once in sections about the headwaters of the Bay of Fundy. The Queen Anne Dike was built in 1877. Its length is a little over 400 rods; its average width at the bottom is 16½ feet; average height on the sea side, 7 feet; average width at top of the dike, 3½ feet. This dike cost $6 per rod. Work was commenced upon it in April and continued till ground froze in the fall. A large *aboiteau* was built across Winchester's Creek, which discharges into Annapolis Basin. This *aboiteau* is 35 feet wide at the bed of the creek, 35 feet in in height, and 15 feet wide on the top. The sluice-way is in three divisions, each 14 by 16 inches. This *aboiteau* cost $2,300. Although the common tides in the Annapolis Basin have a vertical rise of about 25 feet, there is comparatively little force to them, and, as I have just said, methods of repairing the old dikes are in use here which would not for a moment be thought of at the Basin of Minas or about the head of the Bay of Fundy. One of these methods is the facing up of the sea surface of a dike, where a break has occurred or a weak place is notice-

able, by means of planking attached to timber with wooden pins. Such work would not resist the Grand Pré or Sackville tides. The action of the water would be sure to rip out the planking in a very short time.

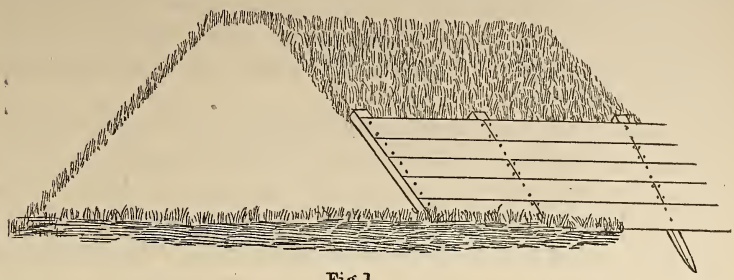


Fig.1.

Another way of protecting the outer surface of a dike in Annapolis and the adjoining towns is by driving outside the base of the dike large stakes, about 1 foot apart, and weaving in withes, much as a fish-weir

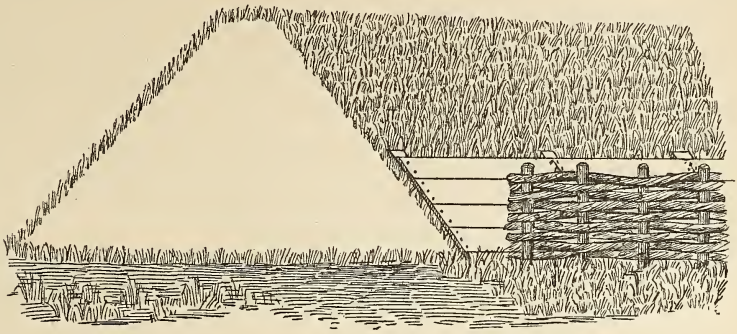


Fig.2.

is constructed, with the exception that the withes must be crowded down and earth filled in between them and the outer surface of the dike. In Annapolis County many of the old French dikes were built

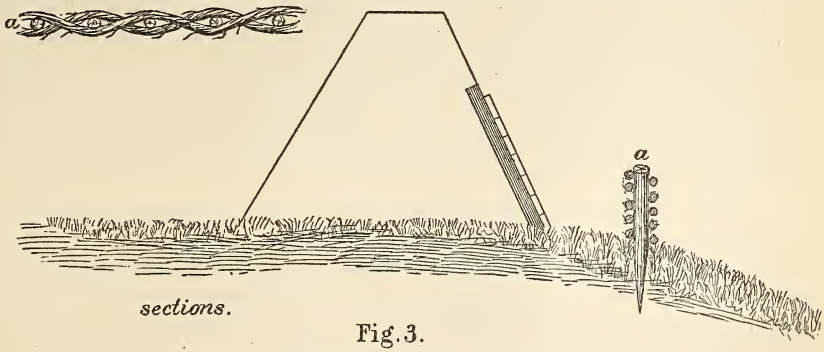


Fig.3.

with a very upright outer surface, and in localities where there is little roll to the sea such dikes serve a good purpose and are cheaply built.

At Grand Pré the embankments, though old, are in most excellent condition. Few new dikes are needed, and all the land in the vicinity is already brought under improvement.* The best examples of diking which I examined in the provinces were at Amherst, Nova Scotia, and near Sackville, New Brunswick, where are the extensive reclaiming works before spoken of. At most other places visited the dikes are old and need but small annual repairs.

Coming to the practical details of dike construction, I wish to say that I have embodied below the results of long and minute interviews with some of the best dike-builders and most experienced commissioners of dikes in both provinces. Of course, as my schedule of inquiries was addressed to each person, there would be much repetition should I attempt to give the answers of each one. Instead, I prefer to embrace the information from each in a general statement, placing before the reader what I deem best and most correct from all of them, giving my acknowledgments in a concluding note. Information has also been gathered upon many useful points not comprehended in the schedule of inquiries prepared by the Department for my guidance.

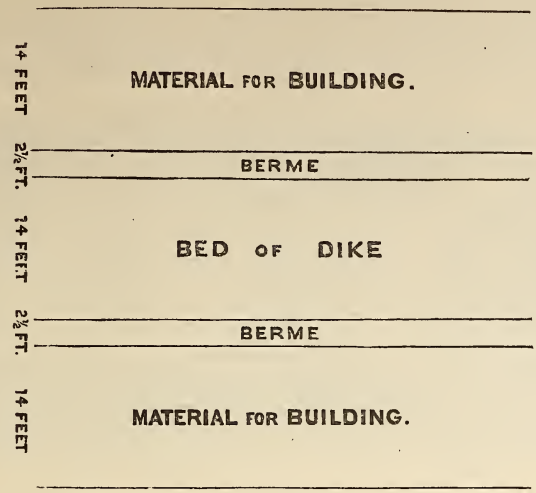
The best season for building a dike is generally after the heavy spring tides have passed. It is then that the grass on the sods used in building the dike grows and unites more firmly than at any other season. The fall is a good time to build dikes, because it is a leisure time with workmen and wages are low. When the Queen Anne Dike was built, in 1877, men were hired for from 60 to 70 cents per day and board. June is the best month in which to build an *aboiteau.*

In proceeding to build a dike, it should be placed directly upon the sod of the marsh where it is to be built. Sometimes the turf is taken off in places to "level it up," as the term is, but not in general. Occasionally the marsh where a dike is to be built is soft, and where this is the case it is frequently the practice to cut down into the surface the depth of a spade (spit), about 12 inches, exactly in the center of where the dike is to stand, making a ditch 18 inches wide, then build the dike over it. This acts as a brace or support to the dike. Sometimes dikes built on this soft bottom are moved completely over—"shoved" is the term—by the action of the sea. Long grass left under the dike has frequently caused leaks; it should invariably be removed. Low places in a marsh are liable to settle more than other surface, and these should be brought up higher than the other parts, and kept so as the works progress. Upon an average running dikes are built 16½ feet wide on

* On the Grand Pré Dike is a place much exposed to the sea as it comes rolling in round Cape Blomidon. The ice formerly caused much injury to the dike at this point, and to protect it a long row of oak piles was driven into the flat a few rods from the base of the dike. These piles were a foot through and about 30 feet long, two-thirds of their length being above the surface of the soil. They were driven closely together and presented a most formidable barrier to the action of the sea; but many of them were twisted and broken off by the floating ice cakes.

the base, from 6 to 7 feet high, and not over 3 feet wide at the top. The common plan of laying out the work for a dike may be illustrated by the accompanying diagram. The strip of marsh 14 feet wide in the cen-

Fig. 4.



ter (or wider as the case may be) is for the dike to rest upon. Then upon each side measure off a piece of land 2½ feet wide, known as a "berme," which is to give support to the dike. Then the builder of the dike is allowed a strip of land 14 feet wide with which to build the embankment. Usually but 11 feet of the strip allowed on the *outside* of the dike is used in construction, the remainder being reserved for repairs which are always required upon the outside. Almost invariably the material for the construction of the dike is obtained from the marsh upon which it is built. In some cases the soil over which a dike is to be constructed is so soft and spongy that it is not suitable for the building of the dike, and in that case it would be obtained from near the shore, but never from the upland. Some such circumstance as that just named (a soft bottom) might determine whether the most material should be taken from one side of the embankment or the other. Upland marsh sods when put into a dike to form the outside would invariably be killed, *i. e.*, the grass roots and grass growing upon them, by the salt water. Inside the dike the land is valuable for grass, and hence those building take as much land from the outside for the work as possible. Moreover, the ditch or excavation on the outside is soon filled by the action of the sea. In some sections the custom is *never* to use any material from the inside, with the exception of that taken from the ditch, which is always needed for draining the marsh.

The old French, who were a wonderfully economical working people, and understood as well how to build a dike as those of to-day, adapted the form of embankment to the location. Where the action of the sea

was but slight they built the embankment quite upright on the exposed side; but generally their rule was to give the inside a greater slope than the outside, as it was regarded as a brace. The action of the sea is greater on a vertical than on a sloping surface, and in locations where the sea rolls in heavy the rule is to give the side toward the sea a great slope, as the more slope the less wear.

It will frequently occur that new work has to be united to an old dike. In such cases the two should be tongued or dovetailed together, as in

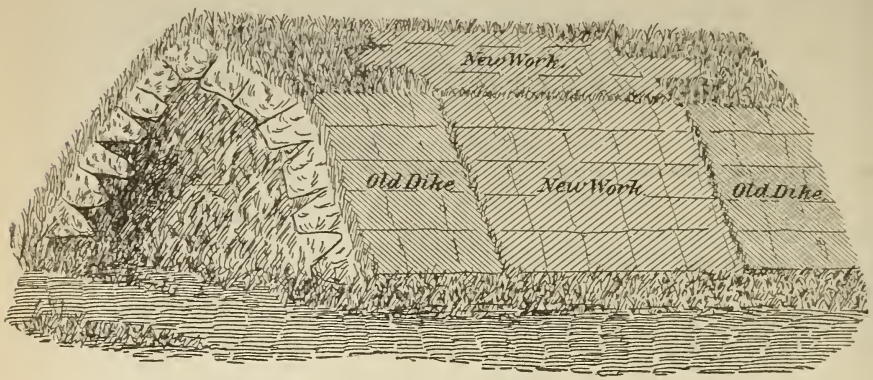


Fig. 5.

joining two pieces of timber. The diagram shows the surface of the embankment where such work has been performed.

In the construction of both running dike and *aboiteaux*, both sods and brush are used. The latter is invariably used in building an *aboiteau*, and in running dike wherever the soil is soft. On no account should the brush be so long as to extend through from one side to the other, as an immediate leak would result. The diagram will show how a dike

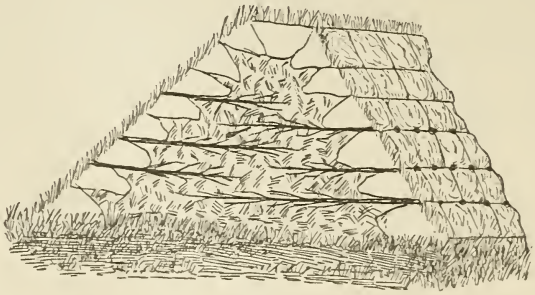


Fig. 6.

should be constructed when these two materials are used, the brush never reaching more than two thirds of the way across. When a dike is in process of construction, if it is necessary to leave it over a high tide, brush should be packed closely over the work and riders (long

poles) put on the brush and pegged down. Where a change of course must be made, a sweep or curve is better than an angle, because the sea takes hold of it with less severity.

In some places, as at Grand Pré, on the river Avon, and along the Annapolis Basin, I found that while teams were never employed in building the dikes formerly, they are now coming to be looked upon with favor. At Grand Pré, Mr. Stewart, the dike commissioner, showed me a piece of new dike then constructing, where oxen had been used to draw the sods upon the dike for interior filling. He thought the treading by the oxen, as they were driven upon the embankment to discharge their load, was a good thing. On the Avon River dikes hand-barrows have been used. At the Tantramar dikes—and I am sure their practices there were first class in every respect—they strongly disapproved the use of teams. "It would make our dikes cost too much," remarked Mr. Lawrison. At that place I saw old dikers "slinging" spadefuls of that heavy bottom marsh soil from 20 to 23 feet, and doing it with apparent ease, at a good "all-day" jog. We could see no need for hand-barrows or ox-teams at such work.

The face sods for a dike, both outside and inside, are called by the old French term *perwang** (or *pewang*); I have heard both used. It is pronounced as spelled. These sods are cut at an angle as shown in the figure, and when in place assume the position there given. They should

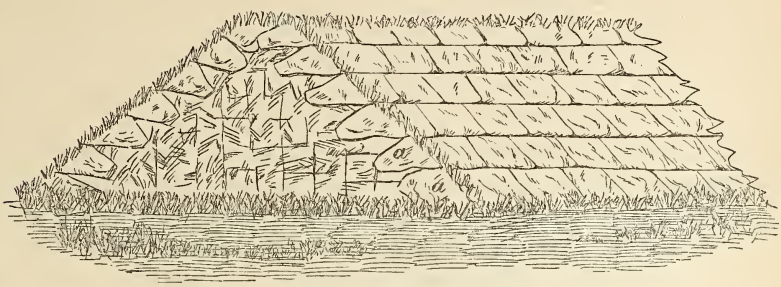


FIG. 7.—*a*, the perwangs.

invariably break joints, like slates on the roof of a building, and if properly laid the dike will in a short time withstand the action of the tide as perfectly as the natural banks of the river.

In constructing a sluice-way it is very necessary that it be placed low enough to thoroughly drain the land. Sluice-ways are most frequently made in three compartments or openings, the timbers securely bolted together with copper bolts. The outside parts are made of timbers and the separations of thick plank. Only green timber and plank should be used. A common opening for moderate-sized creeks is 14 by 16 inches, one, two, or three being used as needed. For a larger amount

* I also found in some sections the word *aboiteau* contracted into *batteau*, and the people who used it seemed to know no other word.

of water an opening 2 by 2½ feet is used, while at the Etter *aboiteau* the sluice-ways were 4 feet square. The sluice-way is constructed, floated into position, and weighted down with rocks; then these removed as the earth takes their place, earth and brush being the sole material used in building even the largest *aboiteaux*. It occasionally happens that if the bottom of the creek is very soft, piling is driven upon which to rest the sluice. The gate to the sluice is called a "clapper," and is hung at the top, 2 to 3 feet from the outward end of the sluice. The hinges of these clappers are of copper or Babbit composition (unless, as in some cases, they are of wood). When a wooden hinge is used it is made in this manner: A piece of heavy, stout timber is securely bolted to the

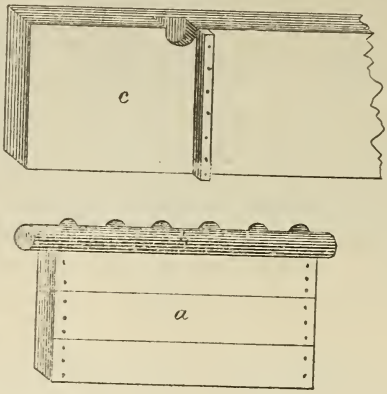


Fig. 8.

top of the clapper with copper bolts, and the ends project a few inches to fit into slots in the sluice-way timbers, ;*a* being the clapper, *b* the header or hinge, and *c* the side timber of the sluice-way, with a slot to receive the hinge. Iron must not be used, for the salt water corrodes it in a very short time. This gate or clapper is placed at a little distance from the end of the sluice-way, in order to protect it from the action of the ice and to secure greater safety and more perfect action. Being hung at the top, it operates freely by the action of the salt and fresh water. The incoming tide pushes it back against the shoulders fitted on the sides of the sluice to receive it, and it makes a perfect dam. Then at low tide the fresh water in the creek pushes open the clapper and goes out to the sea. In no instance did I find any use of siphon, pump, or wheel for the purpose of venting the water from the marsh.

In some years the injury to embankments from muskrats is considerable. Especially is this the case when freshets occur which drive them from their holes. If the drains are kept open and the land dry, they generally do little damage. Sluice-ways and clappers are frequently plated with tin composition (Babbit metal) or copper.

There are several methods of getting at the cost of dikes. One of

the questions relates to the "cost per cubic yard" of constructing the dikes, and another to the cost "per acre of diking and draining" the marshes. But I find the cost of building the dike is reckoned by the rod or "brace." On the great dikes about Amherst and Sackville the latter term is the one most generally employed. The cost of the running dike will vary according to the location, character of the soil, season of year in which it is built, and rate of wages paid per day.* But when the entire cost of all the work is reckoned, including *aboiteaux*, it is assessed *per acre* upon the ownership of the dike. A "brace" of running dike is 6 feet in length, and the price will vary from 75 cents to $1 per brace, *i. e.*, for a dike 12 feet at the bottom and 6½ feet high. But the Queen Anne Dike cost $6 per rod, and about Grand Pré the cost sometimes runs up to $7 per rod. Where the *aboiteaux* are heavy and expensive the cost will reach a sum as high as $70 per acre, but in ordinary cases the cost is from $18 to $23 per acre. The annual cost of repairs and keeping the dike in good order is about 75 cents per acre, but on some large dikes, as at Amherst, it will not exceed 50 cents an acre for a term of three years.

There is great uniformity of treating the reclaimed marsh for the first few years after it is diked—it is let alone. The term used is "to let the salt out," or "let the salt go out." But the reclaimed marsh must first be thoroughly drained after it is diked. The better the system of drains employed, the quicker the land may be worked. Division drains or ditches are provided for first, and the law requires that every joint owner shall make one-half of these division drains. They are usually 3 feet wide at the top, 1 foot wide at the bottom, and on an average 3 feet deep. It takes from three to five years for the dike to become what is termed "fresh"—for the salt to "go out." But it is not always the case that it will do so in this length of time, for on high, dry places the salt really never gets entirely out from the soil. The first and second years after land has been diked it is as salt as ever; then it becomes more fresh, and after the fourth or fifth year it may be plowed. But on this matter of plowing opinions differ. Many farmers think it better never to plow or disturb the sward of a dike if it is to be kept in grass. Notwithstanding this opinion obtains to a considerable extent, the dikes are generally plowed, for crops of wheat and oats are grown upon them. After being plowed the dikes are sown to wheat and oats and seeded down to grass, and heavy crops are raised, 40 bushels of wheat being a common yield. Timothy and clover are the chief grasses, and thrive

*Among statements made to me regarding the cost of making dike and the amount a man could make in a day, a most remarkable statement was given me by Capt. R. Lawrison, of Amherst, Nova Scotia, to whom I am under obligations for much information. This gentleman tells me that he once had two men, brothers, who were building a dike for him at a given price per brace. These men drove 5 miles every morning to their work, put up each five brace of dike, or 30 feet in length, and then rode home 5 miles. The dike was 16 feet deep at the base and 6½ feet high. The feat I regard as a most remarkable one.

wonderfully. The yield of good dikes is from 2 to 3½ tons per acre, and on new dikes 4 tons is not unusual. There is a great deal of white clover upon the dikes, and in some cases alsike clover has done well. The dikes are plowed once in about ten years, and reseeded. At the Grand Pré the dike is not fenced, being all in one body, but on the Tantramar Dike fences are common and much of the dike is used for pasturage. It makes the very best grazing land, much better than upland. Couch-grass (*Triticum repens*) is much esteemed as a dike grass, being invariably cut before its seed matures.

In regard to letting the sea in upon diked land there have been as many differing opinions as in regard to plowing or not plowing the sward. Many farmers used to think the salt water must never be let in upon the dike. But when the great tide occurred, October 4, 1869, called the "Saxby tide," or Saxby gale, all the dikes in both provinces were flooded. It rose 4 feet above the highest storm tides ever before known, and in some places even more. At Sackville, New Brunswick, on the Tantramar Marsh, a vessel of 160 tons was taken over the dikes, and left no mark where it went. Then it was said the dikes were "ruined" for grain and grass production. But, on the contrary, they proved better than ever. This convinced many that it was better to have the sea let in upon the dikes every few years, and the practice—especially on the Sackville and Amherst Dikes—has since then been generally followed. The best time of year to have the sea let in upon the dike is undoubtedly in the fall after the ground is frozen, and shut it off in spring. It is now believed by the best farmers that all dikes should have a dash of tide once in eight or ten years.

In general the dikes are not as unfavorably influenced by a drought as upland. They are more uniform in their product in dry seasons, and unless the drought is very pinching and severe do not feel it. But high places in the dike feel a dry season quicker than those on the usual level.

In the first part of this report I have stated, from careful inquiries, the relative prices of diked land and good quality of upland, and these prices show that the diked land is esteemed far more valuable for grass, grazing, and grain-growing than the best upland. The universal testimony is that the dikes are a long way ahead of the most productive upland. "One acre of dike is better than 2 acres of upland" is an expression commonly heard. They require no manure, yield heavier crops of grass and grain than upland, and after the first three years from seeding the best upland will not make half as much pasture as the diked land. "Pastures on the dike are the best pastures in the world," one farmer said to me. "I want a farm," said another farmer, "having a good junk of marsh; if I have that, I can make my upland what I like." As to disadvantages, there are few of them. Near the bays dikes are more liable to breaks than on the rivers, but these breaks occur very infrequently. The dikes have no stones to pick up and haul

off and few fences to keep in repair, being divided by ditches. They are far superior to upland for grass and grain; yield hay for fifty years with no plowing or manuring, whereas upland only gives good crops of grass for four or five years before it begins to go back; and farm tools, plows, &c., last longer on the dike than on upland.

Very generally throughout Nova Scotia and New Brunswick the most of the marsh lands are reclaimed. There are occasionally small pieces, where heavy dikes are required or expensive *aboiteaux* needed, that have not been reclaimed. Again, some marshes are exposed to a bleak coast, and it would hardly pay to dike them. But even if it cost $75 to $100 per acre to dike them, it would be a paying investment, for after five years they would be worth $200 to $300 per acre. In all my examinations I did not see nor did I learn of an instance where attempts to reclaim marsh lands have proved unsuccessful when the work was properly performed. Occasionally, owing to bad diking, the sea would come in, but instances of this kind are almost unknown. "The more dike we build the more we want to build," said Mr. Lawrison to me when questioned as to the success attending the work.

As before stated, the tides of the Bay of Fundy are loaded with a fine marine sediment. This is never deposited in transit; it is when the water in the bays and creeks is stationary that the deposit is precipitated. Now, if there were no fresh rivers running down into the bays, the channel would be filled up by this marine alluvium. As it is the channels are kept open by the rivers and creeks flowing down through this deposit, and were it not for the rivers the sea would in time build its own dikes. In general, the diking of lands has made no difference in the channels of navigable streams, and so far as I can learn from the most minute inquiry there has been no elevation or depression of lands along the Bay of Fundy or its creeks, at least none of such a nature as to affect their value.

"There can be no plainer matter," said the Hon. Mr. Morse, of Amherst, Nova Scotia, to me, "than that the Government has rights and privileges in those submerged lands lying between high and low water." Parties owning the land own to common tides; but between common or the ordinary high tides and low water is a tract of land which the Government controls. It is the Queen's highway at high tide, and the Government sells fishing privileges upon it. Occupiers or owners of abutting land may use it. It is the opinion of Judge Morse that companies will yet be formed for the reclaiming of these submerged flats between high and low water, and that thus thousands of acres of now unproductive land will be brought into food-yielding crops.

The effect of the reclaiming of these vast bodies of marsh on the public health has been marvelous for good. All the localities where these extensive tracts of marsh have been diked have become much healthier; and especially so in the case of the large extent of fresh boggy land that has been reclaimed about Amherst and on the new Tantramar Dike.

From my observations and studies of the dikes and diked lands of the provinces of Nova Scotia and New Brunswick, I am led to have great admiration for the people who have accomplished so much for the agriculture of those provinces by the means described, and who are yet carrying on the reclaiming and development of worthless lands to so large an extent as to practically create whole townships of the best agricultural lands from worthless bogs and morass. We are sometimes inclined to think our provincial cousins a little slow, and agricultural processes there somewhat antiquated, but the results of my extensive travels convince me that the farmers there are enterprising and progressive, and that in general their methods are highly commendable.

C.—Concluding remarks.

In a country where there are so extensive tracts of diked land as at Amherst, Sackville, Grand Pré, and all about the headwaters of the Bay of Fundy, it is plain that the agriculture of entire countries is founded upon the system of dikes which there exists. "The dikes are the life and soul of our system of farming," said Mr. Lawrison, "as with them we have fat cattle, horses, and sheep; fine dairy cows; can cut hay and sell it and make our uplands just as rich as we please." "We could not stay in the country were it not for the dikes," said a good and intelligent farmer to me at Truro. And these expressions convey a good idea of the great value to the agriculture of these provinces of the diked lands—the best class of soil and the most productive fields of any I have ever examined anywhere. As long ago as 1822 the late John Young, who by his "Letters of Agricola" did so much to improve the agriculture of Nova Scotia and bring about better methods of farm practice, spoke as follows upon the value of these lands: "Sea marsh is a compound, prepared by the laws of nature, of sand, limestone, and clay carried by the rivers, mixed with shells and enriched by the remains of vegetables and animals. In many parts of this province marsh mud is employed as a manure, and is highly beneficial on uplands." Mr. Young continues: "The coast of the Bay of Fundy is unquestionably the garden of Acadia, and accordingly we find that the French planted themselves there on the first occupation of the country. They threw across those dikes and *aboiteaux* by which to shut out the ocean, that they might possess themselves of the rich marshes of Cornwallis and Horton, which prior to our seizure they had cropped for a century without the aid of manuring. The progress they had made in the clearing of the interior was small, but wherever they did encroach on the forest it was in the line and by the banks of the rivers, that they might lay hold of the intervals." Again he says: "Spots in the Grand Prairie of Horton have been under wheat and grass alternately for more than a century past, and have not been replenished during that long period with any sort of manure."

What was true when Mr. Young wrote in 1822 is true to-day. The dikes of Nova Scotia and New Brunswick embrace their richest, most productive, and most valuable agricultural lands. These lands are well husbanded, and the public spirit and enterprise of many of the wealthier citizens of the provinces are now being given to the reclamation and improvement of large tracts of otherwise worthless lands by means of sea-flooding. Such men are surely public benefactors and deserve well of the people.

LEGAL ADMINISTRATION OF DIKES.

In both Nova Scotia and New Brunswick the statutes relating to diked lands and the duties of officers or commissioners of dikes are quite extensive. I have the opinion of Hon. Mr. Morse, the learned judge of the county court at Amherst, Nova Scotia, that the New Brunswick laws concerning dikes and their administration are preferable to those of Nova Scotia. I give below abstracts of the statutes of both provinces. Before giving these abstracts a few definitions will perhaps make the subject somewhat more plain.

The proprietors of any body of marsh may appoint commissioners for such marsh, and the gentlemen so appointed are commissioned by the governor in council as "commissioners of sewers;" or, in other words, the marsh proprietors recommend the men to be appointed, and the governor in council appoints and commissions them. These recommendations, and all acts of the proprietors, must represent two-thirds of the interest in the "level" or entire body of marsh. A body of marsh may be of larger or smaller extent, and have one or more commissioners to superintend its affairs, as the case may require. Usually the board of commissioners consists of three persons, who have a clerk; but often only one, and sometimes five. The proprietors of a level or body of marsh regulate the fall feeding of such marsh as a "common field," and stipulate the number of animals to be put on the "common field" per acre, according to their ages. The commissioners usually have two meetings in each year, one in the spring and one in the fall. All votes are decided by a *two-thirds interest*—not by the number of proprietors or by a majority vote, but by two-thirds of the interest in the body, level, or common field.

I.—The Nova Scotia dike laws.

Abstract of Chapter XL of the Revised Statutes of Nova Scotia (fourth series, 1873), relating to commissioners of sewers and of diked and marsh lands.

Section 1: All commissions shall continue in force till the governor in council shall otherwise direct.

Section 2 provides that the governor in council, at the request of any of the proprietors of any marsh, swamp, or meadow lands, may appoint one or more commissioners of sewers for the county, township, or place

where such lands lie. The commissioners shall be sworn into office by a justice of the peace; the commissioners shall appoint a clerk, who shall be sworn into office by one of the commissioners, all to be recorded in a book as evidence of the fact

Section 3 provides that two-thirds in interest of the proprietors of any marsh within the jurisdiction of the commissioners may, by themselves or their agents, select one or more commissioners to carry on any work of reclaiming such lands, and they may at any time add to, diminish, or choose other commissioners, record being made of the fact in the book of record or filed by the clerk.

Section 4 provides that the commissioners so chosen may require of the proprietors of such lands to furnish men, teams, tools, and materials to build or repair any dike or weirs necessary to prevent inundation, to dam, flow, or drain such lands, to build *aboiteaux;* and in case proprietors neglect to do so, the commissioners may themselves provide them, at the expense of such proprietors. In case of the commencement of any new work, two-thirds in interest of the proprietors shall first agree thereto.

Section 5: The commissioners may appoint from among the proprietors one or more overseers, who shall be sworn, to superintend the work.

Section 6 provides that three days' notice shall be given proprietors of the time and place where the labor is to be done, to attend and furnish materials. In case of a sudden breach in any dike, immediate attendance may be required, or the commissioners may themselves employ men to do it, at the expense of the proprietors.

Section 7 provides that the commissioners may assess the owners or occupiers of such lands for any expense incurred by them in building or repairing the dikes, not to exceed $3 per day for every commissioner while actually employed, having regard to the quantity and quality of land of each owner or occupier and the benefit to be by him received.

Section 8: If such rate shall exceed $1.50 an acre on the whole quantity of ratable land, the commissioners shall summon the owners, when two-thirds in interest of the owners or occupiers present may elect not less than three nor more than five disinterested persons as assessors, who shall be sworn into office, and a majority of them, with the commissioners, shall assess the owners for the expenses incurred, including a sum not exceeding $1.50 a day for each assessor while actually employed.

Section 9: The commissioners for the Wickwire Dike may assess the owners, although the rate shall exceed $1.50 an acre, provided it shall not exceed $4 an acre on the whole quantity of ratable land, without calling a meeting of the owners.

Section 11: Assessments, when agreed to unanimously by owners in writing, to be entered in the books of the commissioners, shall be valid and binding.

Section 12 provides that all fines, rates, or assessments shall be recovered by and in the names of the commissioners, with costs, the same as if they were private debts.

Section 13: In case no goods of any occupier or owner of such lands can be found, the commissioners may proceed, under the judgment obtained, to let so much of the land as will pay the rate and expenses, by first giving twenty days' notice.

Section 14 provides if lands cannot be let for a sufficient sum to pay the rate and expenses, the sheriff or his deputy shall sell so much as is necessary to pay the same, first giving three months' notice; and he shall execute and deliver a deed for the same. No school or glebe lands shall be sold under Chapter XL.

Section 15: Where the present or former owner or occupier of any land, or his known agent, shall not have agreed to the building of any dike, weir, *aboiteau*, or breakwater, or to the damming, flowing, or draining of such land, the land only shall be liable for the rate or assessment.

Section 18: Owners and occupiers of such lands, if they neglect to furnish men, tools, carts, or teams when required by the commissioners, in case of a sudden breach or apprehension of one, shall be fined, and the fines when recovered shall be applied to the benefit of such lands generally.

Section 19: If sods or soil for the purpose of making or repairing such dike be cut off the land of any proprietor, inside or outside the dike, such damage shall be valued, assessed, and paid as other dike rates.

Section 20: The commissioners shall have power to settle all such damage, provided it does not exceed $5 to each person; if the owners and commissioners cannot agree, it shall be left out.

Section 21: The clerk shall keep a record of all proceedings of the commissioners.

Section 22: Whenever by the making or repairing of any breakwater, by direction of a commissioner of sewers, salt marsh lying outside the same shall be benefited thereby, the same shall be taxed and assessed towards the expense of the breakwater in proportion to the benefit derived.

Section 23: Whenever in the draining of any swamp or meadow land a part shall be benefited, the proportion of the expense shall be assessed on that part only.

Section 24: A clerk, overseer, or collector shall be a competent witness to prove any fact connected with the duties of his office.

Section 25: No commissioner shall hold the office of clerk or collector.

Section 26: Commissioners may cause to be made a plan of the land over which they have charge, showing lots and boundaries, names of owners or occupiers, and the owners or occupiers shall be bound by such survey and plan.

Section 27 provides that where any lands inclosed by dikes shall by

other dikes erected outside the same be protected, the commissioner in charge shall call a meeting of the proprietors, and two-thirds in interest of the owners or occupiers present shall determine what proportion of benefit has accrued or is likely to accrue to the lands lying within the inner dikes, and what proportion of expense the proprietors of the lands within the old dikes ought annually to pay towards the maintenance and repair of the new dikes, which shall be assessed and collected as other dike rates.

Section 28: If the outer dikes shall at any time cease, in whole or part, to protect the inner dikes, the lands of the inner dikes shall cease to contribute to the support or repair of the outer dikes.

Section 29 provides that if the proprietors of land in the inner dikes apprehend that the outer dikes are unsafe or out of repair, they may take proceedings to compel the repairing of such outer dikes.

Section 30: If a person pastures lands inclosed by a common dike, or makes a road over such lands, to their injury, he shall be liable for the same.

Section 31 provides how a proprietor of any marsh may apply to the commissioners of sewers to have such marsh diked and drained.

Section 32: Two-thirds in interest of the proprietors of any body of marsh, diked or undiked, may make application to the commissioners to have roads or bridges leading through such marsh built, altered, or repaired, and the expenses of the same are assessed and collected as in the case of ordinary dike rates.

Section 33: On application in writing two-thirds in interest of the proprietors may call for the flowing of any diked marsh, or for the building of division dikes to prevent the flowing of any part thereof, the expenses of which shall be assessed according to the benefit to be received to such part flowed.

Sections 34 to 36 provide for notices to be served in case proprietors are dissatisfied with the work done under section 33, and define mode of procedure in such cases.

Section 37: If the proprietor of any land within the dike has been injured by such flowage (he not being an applicant for the flowing), he shall recover for the same.

Section 38: When any diked marshes are owned by two persons in such proportions that neither is interested to the extent of two-thirds, either party may require one or more commissioners to take charge of and carry on any work necessary for repairing the dikes thereof.

Section 39: If any owner or occupier of land think himself aggrieved by any proceedings of the commissioners, he may have redress by applying to the supreme court, the manner of doing so being detailed in this section.

Section 40: All clerks, collectors, overseers, and assessors who neglect or refuse to comply with their duties shall be liable to a fine.

Section 41 provides how notices required to be given may be served.

Section 42 provides that two-thirds in interest of the proprietors may choose collectors and other officers and settle all rates of wages for work done.

Section 43: No commissioner shall be liable for any act of his predecessors in office.

Section 45 provides that any individual proprietor may make improvement on his own land which he desires to make, independently of the commissioners or of the provisions of this chapter, provided he is held liable for any damage which may result to the land of other proprietors by deepening or widening of water-courses or drains, and provided that if it is necessary to cut any drain through any dike or marsh land not owned by him he shall notify the commissioners, and it shall be done under their supervision.

Sections 46 and 47 make provision for the appointment of joint commissioners on the part of the province of New Brunswick for the supervision of the Missiquash Marsh, located on both sides of the boundary line between New Brunswick and Nova Scotia, and define their powers and privileges.

II.—The New Brunswick dike laws.

Abstract of Chapter CXV of the Consolidated Statutes of New Brunswick, 1877.

Chapter CXV of the Consolidated Statutes of New Brunswick, relating to "sewers and marsh lands," is divided into seven parts.

Part 1, of two sections, provides for the appointment by the governor in council of commissioners of sewers and special commissioners to superintend the reclaiming, draining, and inclosing of marsh, low meadow, or unreclaimed lands.

Part 2, of nineteen sections, provides for the division of marsh lands and the election of commissioners in the county of Westmoreland (except the parish of Sackville) and in the county of Albert. This part relates to the bounds of the divisions, determines the time and place for the meetings of proprietors, provides for the election of commissioners, defines their duties, establishes the rate, and prescribes how a district may be withdrawn from the jurisdiction of the commissioners.

Part 3, of ten sections, provides for the division of marsh lands and election of commissioners in the parish of Sackville; the several sections relating to the details the same as given for part 2.

Part 4, of one section, relates to the making of roads through certain marsh lands.

Part 5, of two sections, provides for the appointment of commissioners of sewers for Queens County.

Part 6, of two sections, relates to the appointment and powers of the Missiquash commissioners of sewers, this body of marsh being on both sides of the boundary of New Brunswick and Nova Scotia.

Part 7, of thirty sections, gives the general provisions; of which a brief abstract is presented herewith.

Section 1: The commissioners of sewers may meet as often as occasion may require to devise means for building, erecting, or repairing *aboiteaux*, dikes, or weirs, for preventing inundations, for draining or drowning marshes, employ workmen, and assess or tax the owners of such lands for defraying the expense thereof, having regard to the quantity and quality of land of each person and the benefits to be received, as equally as they can, and to appoint all officers to act under them.

Section 2: The commissioners shall appoint a clerk, who shall not be a commissioner, and a collector, both of whom shall be sworn.

Section 3: The commissioners shall be sworn.

Section 4: The commissioners are empowered to carry into effect such rules and regulations as may be made relating thereto, and assess the proprietors for the necessary expense.

Section 5: Each commissioner shall receive for superintending the diking of any land $2 per day, and for other services as commissioner $1, to be paid out of the assessment.

Section 6: Six days' notice shall be given of erecting new dikes or *aboiteaux*, or raising or repairing the same, by advertising the same in three public places within their jurisdiction.

Section 7: Upon such notice proprietors or occupiers shall appear with workmen and tools for the purpose mentioned, according to the proportion of land belonging to each owner or proprietor.

Section 8: Oxen and carts shall be called for from proprietors if their work is necessary.

Section 9: In case of a sudden breach in any dike, or expected breach, the commissioners will give immediate notice to proprietors to attend and repair the same.

Section 10 provides that the commissioners shall have no power to dike in any body of marsh unless upon the application or consent of the proprietors of at least one-half of the quantity thereof to be benefited thereby.

Section 11 provides that the commissioners shall tax and assess all persons benefited by such dike according to their discretion, but not above the real value of such reclaimed or inclosed land.

Section 12: The commissioners shall have power and authority, by and with the consent of the proprietors of a majority of acres to be benefited, to cut through and appropriate so much of any body or district of marsh, bog, or low lands as may be necessary for cutting any canal or ditch and for making any dike thereon, and for draining or flooding any body of marsh, bog, lake, or low lands under their supervision.

Sections 13 to 15 provide that if proprietors are injured more than benefited by such canal or ditch, the commissioners shall make compensation; and in case they cannot agree, the same shall be decided by five competent freeholders, to be summoned in manner given.

Section 16: The commissioners shall have power to make assessments from time to time as the work progresses, and settle the same every three years and before their term of office expires.

Sections 17 to 19 provide that the commissioners shall make up a bill of assessments, leave the same with the clerk for inspection, and give notice thirty days before issuing a warrant to distrain. If, after such provisions as are given have been complied with, the assessment is not paid, the commissioners may cause a warrant of distress to be issued against the delinquent proprietor, proceeding as in manner set forth in Chapter LX, relating to justices' civil courts.

Section 20: When commissioners have proceeded or acted, with the consent of a majority of acres of the proprietors of any body of marsh, in such manner, such costs and expenses shall be assessed and collected in like manner as ordinary expenses are assessed and collected.

Section 21: Any commissioner guilty of willful neglect or gross negligence in performing his duty shall be personally liable to the party injured for all damage in consequence of such negligence, such damages to be recovered, with costs, in an action on the case in any court of record.

Section 22: Any owner or occupier of marsh lands neglecting to attend, on due notice of the commissioner as in section 7, to perform the work required, shall forfeit and pay for such neglect $1 for each day's neglect, and so in proportion, for carts and oxen.

Section 23: Any owner or occupier of marsh land neglecting to comply with the notice and direction of the commissioner as in section 9 should forfeit and pay the sum of $2 for each day's neglect, and so in proportion.

Section 24: The penalties provided for in sections 22 and 23 shall be paid to the commissioners, who shall sue for the same, for the repairs of the dikes.

Section 25: Such penalties shall be in addition to the taxes or assessments levied upon the lands of the parties so fined.

Section 26: The words "marsh" or "marsh lands" shall, as used herein, extend to and mean diked marsh, and low lands, bogs, and meadows.

Blank schedules and forms mentioned in this chapter then follow, for the guidance of the commissioners.

Chapter CXVI of the Consolidated Statutes of New Brunswick relates to certain marsh lands in the city and county of Saint John, and in the parish of Lancaster, near Saint John, providing for the appointment of commissioners for the same, defining their powers, regulating assessments, &c.; but the general provisions of this chapter do not in any sense differ from the general provisions as prescribed in Chapter CXV.

VIII.—TIDE LANDS OF WASHINGTON TERRITORY.

FROM STATEMENTS BY ELDRIDGE MORSE.

FORMATION AND GEOGRAPHY OF WESTERN WASHINGTON.

In its formation, soil, climate, and productions Washington Territory is peculiar. The eastern parts of the country furnish no parallel. It may be well, therefore, to refer briefly to the formation and general character of the country and the building up of the tide marshes before passing to a detailed account of these marshes and their reclamation.

Ice, earthquakes, and volcanoes played an active part in giving Washington its present features. The Cascade range of mountains, with an average height of 6,000 feet, extends from north to south across the Territory, without a break. East of these mountains the climate is very dry and the timber scant; westward is a moist climate, heavy timber, and little prairie land. From 50 to 75 miles west of the summit of the Cascade Range are the waters of Puget Sound, and 100 miles beyond the sound is the Pacific Ocean. Between the sound and the ocean the rugged Olympic Mountains rise 4,000 feet, with peaks 8,000 feet above the sea. The Strait of Fuca, 100 miles long, is north of the Olympic Mountains, and connects Puget Sound with the ocean.

On the eastern slope of the Cascade Mountains the descent is gradual: on the western, abrupt. West of the summit of the mountain range, from Mount Saint Elias, in Alaska, to Mount Whitney, in Southern California, are many large volcanoes, most of which have probably been active within recent times. Of these volcanoes only Mount Shasta, in California, and Mounts Rainier and Baker, east of the sound, will be particularly referred to in this article.

It is probable that during the Tertiary epoch the Cascade Range reached its present elevation. At first there seems to have been little or no breaking of the surface. Coal-bearing strata and fossiliferous rocks covered the summit, and the descent towards the ocean was as gradual as it is now to the valley of the Columbia. It is likely that at this time there was no break in the Cascade Range from Alaska to Southern Oregon. The cañons of the Frasier and Columbia Rivers did not exist, and the only outlet to the ocean for the country now drained by these rivers, and the Great Utah Basin, was through the gap left

between the south end of the Cascades and the north end of the Sierra Nevada Mountains, and the region afterwards dammed up by Mount Shasta. It is a singular fact that gold, so plentiful on the western slopes of the Sierra Nevada Mountains, in California, is found in large quantities only on the eastern slope of the Cascades through Oregon, Washington, and British Columbia. It is more than probable that the deep-gravel, placer, and cement gold mines of California received the larger part of their precious deposit from east of the Cascades, and that it was brought there in prehistoric streams that drained these regions before the great laval outflow that covered Northern California, Eastern Oregon, and Eastern Washington.

It is probable that during all the Glacial epoch the drainage of the country east of the Cascades was through this gap, over the present site of Shasta, into the center of California. Glacial action is far less marked in Eastern than in Western Washington. The great lakes then existing there protected the country east of the Cascades, while west of that range everything favored an immense deposit of ice and snow, which moved with resistless force to the ocean and leveled all obstacles in the way.

As the era of ice passed, volcanic forces came into play. The forces that had been sufficient to raise the mountains lost their power, the internal fires cooled somewhat, and the sides of the mountains began to shrink and settle. Much of this may have occurred during the Glacial period, but the great volcanoes before referred to in all probability arose after its close. The forces that were insufficient to hold up the sides of the mountains were ample to raise, through the fissures formed by their settling, mountains from 10,000 to 15,000 feet high, like Baker, Rainier, Hood, Shasta, &c. During this era of volcanic upheaval the earth probably settled throughout the Puget Sound region over 1,500 feet, and fissures 100 miles long and miles in depth were formed, into which the sea rushed with fury. This was no isolated phenomenon, but extended 1,500 to 2,000 miles along the coast, from Southern California to Mount Saint Elias, in Alaska. When quiet was restored there was a chain of volcanoes and a great inland water passage where had been a high plateau between the Cascade and Coast Ranges. What is now the Lower Columbia and the valley of the Willamette was the great Willamette Sea, while from Shasta to Tulare Lake was another inland sea, 500 miles long, all except the harbor of San Francisco now filled by "slickens" from the mountains.

The drainage of the country east of the Cascades having been stopped by the rocky walls of Shasta, forced for itself a way through what is now the Klamath Lakes and Klamath River region into the ocean. It was only after the earthquake and volcano had done most of their work west of the Cascades that the internal fires beneath this range cooled so as to contract the mountain lengthwise and cause it to split across from summit to base, and thus open the cañons of the Fraser and Co-

lumbia. This last process completed the drainage of the eastern portions of British Columbia, Washington, and Oregon, as well as the Great Basin of Utah. West of the mountains the great seas were gradually filling with sediment, and a genial climate covered the glacial drift with an immense growth of vegetation, until the characteristic features of Puget Sound presented themselves.

There were breaks in this chain of progress, for although the era of continental glaciers did not return, yet the peaks of Baker and Rainier became local centers of glacial dispersion, following the courses of present river valleys, within recent, perhaps historic times, almost or quite to the waters of Puget Sound. Some of these glaciers, following their tortuous courses down the mountain valleys, were 100 or 150 miles long. Now they are shrunken and hid in the deepest valleys. In application to the subject in hand it may be said that after the ancient glaciers, the volcanoes, and earthquakes made the upland country and the plains, the smaller, local, and recent glaciers, by grinding the rocks, furnished the sediment of which the rivers have made the *bottom lands* and *tide marshes* of Puget Sound.

So far only results have been presented. It would take a volume to give the proof in detail, and as that proof is foreign to the objects sought here, it will not be attempted. It is sufficient to state that faults and fissures 200 miles long, the presence or absence of fossils of a given age, and the marks of the glaciers, both local and general, furnish conclusive proofs of the truth of most if not all of the positions assumed. The application of the matter already presented will more fully appear in describing the several parts of Puget Sound and the growth of river valleys in old arms of the sound, and in tracing differences of soils to the sources from which the sediment composing them was derived.

LOCAL GLACIERS.

By this term are meant glaciers formed after the close of the true Glacial period and since the channels of the sound were opened. The glaciers from Mount Rainier have extended far down into the valleys of the Cowlitz, Nisqually, Puyallup, and White Rivers, but never over the general level of the upland. Confining themselves to the valleys, theyhave left but little gravel and few bowlders.

Glaciers also extended down all the streams flowing from Mount Baker. A description of one will be sufficient. Baker River, draining its southern slope, has been the scene of intense glacial action. The whole valley of that stream has been filled by a glacier, which, issuing thence, crossed Skagit Valley to the highlands southward, then turned towards the sea and filled the valley for 15 or 20 miles. This glacier was 10 or 12 miles wide in the Skagit Valley, and dammed the waters above it so as to form a lake. Hence, all the lands around the mouth of the Sock and along the Upper Skagit, from the mouth of Baker River up to Portage Cañon, were formed from sediment deposited in a lake,

and when the glacier disappeared and the river cut its channel anew, it left these fine, high, bottom lands above the reach of freshets.

The glaciers are now confined to the deepest valleys and highest slopes of the mountains, and their results are small compared with the changes of the Glacial period, though they still are doing a tremendous work. Each river draining a glacier field is milky white most of the year, from the volcanic ashes, scoriæ, and pumice stone which the glaciers grind. The Skagit, the Nootsack, the White, the Puyallup, and the Nisqually are all *white rivers* during portions of the year. Most of this very fine sediment reaches the lower courses of these streams and contributes largely towards forming the marshes.

THE SOUND.

As Rainier, Baker, and the Olympic Mountains arose, the material that formed their massive sides was withdrawn from beneath the sound basin, and, as it settled, the earth was fissured in every direction. Then, as the fires that supported these volcanoes cooled, there was more shrinking of the strata, until finally the whole sound basin had settled upwards of 1,500 feet.

When the earthquake and volcano had done their work, and all the passages of the sound were first open to the sea, there was no *bottom land*, and the channels were even narrower and deeper than at present. Tides, currents, and other agencies have since been at work wearing back the shore lines and filling the channels. The sound is becoming wider and shallower, and the rivers are filling the arms and bays into which they flow with sediment, extending the flats and raising the level of the marshes.

It is not probable that the sound had its final outline before bottom land began to form, but as it will be of no advantage to trace that matter, it is assumed that the volcano and earthquake had done their work before the local glaciers, frost, rain, and rivers began to fill the sound.

The Strait of Fuca is the outlet for the waters of the Gulf of Georgia and Puget Sound. In its most restricted sense the term "Puget Sound" is applied to an area not exceeding 100 square miles above the Narrows. It is *commonly* held to include all the arms of the sea in Washington Territory of which the Strait of Fuca is the outlet. In its most extended sense the term "Puget Sound" includes the Strait of Fuca also.

The Strait of Fuca, from the ocean to Victoria Harbor, 60 miles, is 12 miles wide. It widens at its head, and, with bays and inlets, covers in all 1,600 square miles. The waters between Vancouver's Island and the mainland, south of the British boundary and north of the head of the strait, amount to 2,400 square miles. The waters of the sound extend 100 miles southward from the head of the strait, and comprise many bays, inlets, passages, and harbors, amounting to about 1,100 square

miles, giving for all the arms of the sea south of the forty-ninth parallel, including the Strait of Fuca, a total area of 5,100 square miles.

CHANNELS FILLED BY RIVERS.

The general elevation of the upland of drift formation in the Puget Sound Basin is from 200 to 300 feet. There were in this region many lakes and other receptacles for sediment which have been filled with fertile soil, but never having been connected with salt water, they, as well as the alluvial marshes along the upper courses of the rivers, may be excluded from these estimates.

Every considerable river, excepting the Nootsack, runs in its lower course through an alluvial valley formed from its sediment. These rivers, although geologically of the present age, have extended their valleys out into deep channels of the sound, in some cases 50 miles. Over these large areas the tide ebbed and flowed, and they were in all respects parts of Puget Sound.

Above the Narrows, at the southern extremity of the sound, the Nisqually is the only considerable stream. Having its source on Mount Rainier, it is confined between rocky walls until it reaches the open plain, where it widens, to be again contracted as it flows through a narrow, deep cañon a few miles from its mouth. Below this cañon it has filled 10 square miles of the original sound. Probably 30 square miles of the former area of the upper sound, above the Narrows, have thus become land, of which over one-half is tide marsh.

Hood's Canal, the southwestern branch of Puget Sound, formerly extended 12 or 15 miles up the Skokomish and covered 25 square miles now bottom and marsh. Other streams have taken as much, so that Hood's Canal has been reduced from 200 to 150 square miles.

On the west side of Admiralty Inlet, the main southern extension of the sound, on Bainbridge and Vashon's Islands, and in the smaller bays and harbors on that side, 25 square miles of tide marsh and bottom have been formed in the channels of the inlet. At the head of Admiralty Inlet, Commencement Bay once extended 15 miles farther up the Puyallup River than at present and covered 30 square miles now land, while north of the Puyallup to Seattle, in the valleys of the Stuck, Green, White, Black, Cedar, and Duwamish Rivers, and the region around and back of Lake Washington, Seattle Harbor, and Salmon Bay, there are 70 square miles of land filling old channels of the sound. On the west coast of Whidby Island and on the east side of Admiralty Inlet are tracts of made land that would foot up nearly 20 square miles.

The next river valley north of Seattle is the Snohomish. The Skagit is the only valley on the sound larger than the Snohomish. Something over 20 miles from its mouth the Snohomish is formed by the union of the Snoqualmie and Skykomish. The Snoqualmie is considered the main stream. Snoqualmie Falls are about 50 miles by the course of the

valley and 75 miles by the channel from the mouth of the Snohomish. Light-draught steamers have ascended to within 2 or 3 miles of the falls; but the head of certain navigation for steamboats, at all seasons, is at Snohomish City, 15 miles above the mouth of the Snohomish by steamboat channel. Snoqualmie Falls are 280 feet high, and are celebrated for their beauty. There is no doubt that the tide has ebbed and flowed the whole length of the Snohomish and up the Snoqualmie to these falls, also up the Skykomish some 15 miles, and a greater or less distance up several smaller tributary streams. The total area of channels of the sound now occupied by the Snohomish and its tributaries would equal or exceed 200 square miles.

The Stillaguamish River is in the northern part of Snohomish County and drains the country between the Snohomish and Skagit Rivers. The South Fork of the Skagit, called the Sock, runs back and to the eastward of the North Fork of the Stillaguamish, while the North Fork of the Snohomish, the Skykomish, runs to the eastward of the South Fork of the Stillaguamish. Surrounded thus by two large streams, the Stillaguamish does not extend back to the summit of the main Cascade Range. Its valley, with the tide flats at its mouth and on the eastern shore of Camano Island, now covers an area of some 50 square miles, where were formerly arms of the sound.

"Stillaguamish" comes from repeating the same thing in different languages. It was known among the Indians as the "Guamish." "Mish" is a general term for river among these Indians, and "gua" means little. "Stoluck" in the Chenook jargon also means river, and Chenook is the usual means of communication between whites and Indians; but they are apt to repeat words several times, first in Indian, then in Chenook, and then in "*delate Boston*," or English. "Stoluck" (river), corrupted into "stilla," "gua" (little), and "mish" (river), give "Stillaguamish"; so in "Stillaguamish River" we have "little" in one and "river" in three languages. This termination "mish" is unnecessary, and many names are much pleasanter to the ear without it. Thus, "Snoho" for "Snohomish," "Sa" for "Samish," "Duwa" for "Duwamish," &c.

The southwestern corner of Whatcom County is the center of the tide-marsh interests of Washington Territory. The marshes here, and a great part of those around the mouth of the Stillaguamish, were formed by sediment brought down by the Skagit. This river rises in British Columbia, and flows east, southeast, and south, around the northern and eastern slopes of Mount Baker, then turns towards the southwest and flows through a series of cañons some 25 miles. Here the spur of which Baker is the highest peak was rent from the main range. On either side mountains rise 7,000 feet. It is probably the highest and one of the wildest parts of the Cascade Range. In some places the tops of the cañons, 2,000 feet above, are only half the width of the river. Tunnel Cañon, one-half mile long, viewed from either end seems closed at the top. Its first explorers supposed such to be the case and called

it the "Tunnel," but subsequently parties reached the summit and found that it did not join. In that vicinity many streams flow into the Skagit through similar cañons. One of these, Ruby Creek, emptying near the head of this series of gorges, was the scene of the Skagit gold-mining excitement of 1879 and 1880. One party of prospectors was caught in this wilderness by the "big snow" (12 feet deep on a level), and was twelve days in going 16 miles. After a trail was opened, this distance was less than a day's journey. By making one portage through or around Portage Cañon canoes could reach Goodell's Landing. Thence 16 miles to the mouth of Ruby Creek the river is so full of rocks, falls, and other obstacles as to be impassable. Above this series of cañons canoes can pass nearly to the source of the Skagit. The total length of this river is about 175 miles, but its drainage area is as great as most rivers 300 or 400 miles long. After getting out of the mountains it turns gradually to the westward, and receives several large tributaries from the east and southeast, which drain all the western slopes of the main Cascade Range to a point nearly due east of the mouth of the Snohomish River. The Sock is the largest of these. It comes from the southeast and flows into the Skagit 62 miles above its mouth. Eight miles below the mouth of the Sock is Baker River, which drains the southern slopes of Mount Baker. Steamboats have been up the Skagit within 1 mile of Portage Cañon, that is, by the river channel, 75 or 80 miles from its mouth. It is probable that originally arms of the sound extended up the Skagit to Portage Cañon, and embraced portions of the valleys of Sock and Baker Rivers. From this cañon to Whidby Island there was once an arm of the sea as long and wide as Admiralty Inlet. It is now all bottom or tide-marsh land.

Where did the Skagit get material for such large deposits? First, it drains the western slope of the Cascade Range for a space over 100 miles wide, where it is highest and glaciers are still doing their work. Throughout this region the main range averages nearly 7,000 feet high. Second, the Skagit drains three sides of Mount Baker, where for many centuries the glacier has been grinding volcanic ashes, pumice stone, and basalt for the river to spread in its lower courses.

The area of this old arm of the sea filled by the Skagit, and which we shall call Skagit Inlet, may be gathered from the following: In Whatcom County, within 12 miles of salt water, there are over 160 sections or square miles of *made* lands, formed of sediment brought down by the Skagit. On Whidby, Fidalgo, and other islands are tracts similarly formed that will equal 15 square miles. Including lands formed by the Skagit around Stillaguamish, &c., over 200 square miles of tide-marsh and bottom lands have been formed by the Skagit, in old arms of the sea, within 12 miles of the present shore lines of the sound. But the Skagit Inlet extended nearly 50 miles farther back into the mountains. It was in some places 10 miles wide, and had great arms, wide and deep, extending many miles farther, as at the Sock and Baker Rivers; there-

fore, the original size of Skagit Inlet, now filled by sediment and turned into tide-marsh or other bottom lands, was not less than 500 square miles, the present size of Admiralty Inlet. This estimate includes the Samish, as formerly the Skagit emptied one of its channels into Bellingham Bay, and only a trifling part of the Samish Flats were deposited by the Samish River. Back of the tide-marsh sloughs the Samish is an insignificant stream, scarcely worthy of being called a river. One branch drains Samish Lake, in a direct line 5 miles from salt water, while the other drains a fresh-water marsh just north of the Skagit, which was formed of sediment deposited by the Skagit.

Writers who take their information about this section from old maps have trouble in locating Swinomish and Swoolamish Rivers. They try to find their sources between the Skagit and Samish, and seek to extend them to the summit of the main range. Neither of them exists as a river. The first, Swinomish Slough, is a tide-marsh slough, which runs from Skagit Bay norhtward to Padilla Bay, the southernmost branch of Bellingham Bay. This slough is about 9 miles long and separates the Swinomish tide-marsh flats from Fidalgo Island.

The Swoolamish River is now called Sullivan's or Calhoun's Slough. It drains a beaver marsh east of the Swinomish Flats and south of the great Olympia Marsh, runs nearly parallel with Swinomish Slough and about 1 mile east of it, then turns eastward and drains a marsh of several thousand acres. At high tide this slough at its mouth appears to be larger than any river on the sound, but at low tide there is only sufficient water for a small boat. A boat's crew pulling across its mouth at high tide would suppose it was a great river, and so it was described until the settlement of that section proved the contrary.

The Nootsack Valley is different in its formation from every other valley on Puget Sound. It is the only considerable river valley that does not occupy an old channel or arm of the sea. The Nootsack runs between spurs of the mountains, and drains the western slopes of Mount Baker, until, reaching the open country, it follows the summit of a low ridge, and in times of freshets sends its surplus waters by many small channels to the Fraser. For this reason it is costly and difficult to reclaim some of the marshes of the Lower Fraser. Like all other Puget Sound rivers, the Nootsack is very crooked. The mouth or outlet into Bellingham Bay is the Lummi River, and the other channel, into the Gulf of Georgia, the Nootsack, or "the old channel of the Nootsack." Only the Lummi Channel is now navigable, as jams prevent the use of the other. Some 50 miles by the river above its mouth the Nootsack forks, and the North Fork runs near the British boundary and drains the higher parts of the northern and northwestern slopes of Mount Baker.

The Skagit rises north and many miles west of the source of the North Fork of the Nootsack, and they pass each other, the Nootsack draining the higher reaches of the mountain and flowing west, while

the Skagit drains a lower level and flows east and then south. Lower down on the North Fork of the Nootsack are falls perhaps equal in height to those of the Snoqualmie. Below this the North Fork receives a tributary called the Middle Fork, which drains the western slope of Baker, and is the outlet of two glaciers on the western side of that mountain. These glaciers make the waters of the Middle Fork creamy white. The South Fork of the Nootsack drains the southwestern slopes of Baker. For some 30 miles its channel is only 10 or 15 miles distant from the Skagit, their courses being nearly parallel; then, within 15 or 20 miles of salt water, it makes nearly a right angle, flowing in the rear of the Samish country and Whatcom Lake, and extending northward 20 miles or more until it joins the North Fork. After their union it has still nearly 50 miles to flow before it reaches the sound.

The South Fork is called in the Indian tongue by a name meaning "clear water," and is one of the clearest and most beautiful mountain streams in the world; but at its union with the North Fork the waters of the Middle Fork make the stream thick with sediment. Thence to the sea the Nootsack flows through a comparatively level country, and its waters are nearly up to the general level of the land. Forty miles from its mouth its waters are from 50 to 100 feet higher than the waters of the Fraser, due north of it. Hence much of the sediment of the Nootsack has gone to form the Fraser bottoms and marshes, and there are some 50 square miles of marshes along the lower course of the Nootsack that are lakes filled with sediment by that stream. While the Nootsack has brought and still brings great quantities of sediment, yet it has not built out into the sound, or rather the Gulf of Georgia, more than 5 miles. Even though a narrow channel ran up 5 or 10 miles farther, the old channels of the sea filled by the Nootsack do not exceed 20 square miles.

It appears, then, that of the 2,250 square miles originally occupied by channels of the sound 1,050 have been converted into land that can be cultivated. Of the remaining 1,200 square miles 200 have been filled so far as not to be navigable for deep-water craft, and the average depth of the whole is probably less than a half of what it was when the fissures were formed.

TIDES AND CHANNELS.

Perhaps no other system of inland waters offers so fine a field for the study of tidal action as that connected with the Strait of Fuca. No analysis of the subject will be here attempted beyond presenting some of the most general features, and particularly those which affect tide-marsh interests.

At Simpson's Narrows, the north end of the Gulf of Georgia, which is several times larger than Puget Sound, there is only 1 mile of water between Vancouver's Island and the mainland, while the narrowest part of the Strait of Fuca is 11 miles wide. From this it will be seen

that the tidal outflow from Puget Sound, and nearly all from the Gulf of Georgia, is through the Strait of Fuca. With each change of tide the current flows up or down this strait like a rapid river. Among the islands and in many of the narrower channels the current is far too swift to row against.

At the head of the sound are Big Skookum and Little Skookum Bays, long, narrow channels, up and down which the tide flows with great velocity. The word "skookum" in Chenook means strong, and is applied to a mountain stream or any swift flowing water.

The Narrows, connecting the upper sound with Admiralty Inlet, are the outlet for 230 square miles of water. Here the tides flow so swiftly that when joined by a head wind steamers are frequently brought to a stand.

Tidal action, owing to the length and outline of the various channels, is so irregular that a separate study of each is needed before general conclusions can be drawn. Thus, Deception Pass, a channel a few hundred feet wide, separates Whidby Island from Fidalgo Island. The tide flowing up Admiralty Inlet and around the south end of Whidby Island, then through Port Gardner Bay and Saratoga Passage into Skagit Bay and up the Skagit, is two hours later than the tide coming up the strait to Skagit Bay through Deception Pass. Therefore when it is low water in Skagit Bay the tide has been coming in two hours through the pass, and when it is high water in the bay it has been flowing out through the pass two hours. This difference of level causes currents of almost inconceivable swiftness in Deception Pass. Only at certain stages of the tide is it safe for any vessel to go through the pass. When the waters on both sides are at the same level any kind of craft can go through with perfect safety, but an hour later the waves roll and the waters run so swiftly that to avoid the rocks on either hand requires skill and care equal to that shown in running the Cascades of the Columbia.

The Swinomish Slough, which connects Skagit Bay with Padilla Bay, is narrow, crooked, and shoal, navigable only for light-draught steamers. One effect of the differences of level between Skagit Bay and Bellingham Bay is that the current flows northward through Swinomish Slough from Skagit Bay into Padilla Bay, as the southern extremity of Bellingham Bay is called, nearly all the time. The reverse current southward does not exceed two or three hours out of twenty-four. This makes Skagit Bay the place of deposit for the sediment of the Skagit River, and accelerates the process of tide-marsh building. Swinomish Flats may be, and in this account are, regarded as a part of the Skagit Delta, and the Swinomish Slough and Deception Pass as prolongations of the Skagit River. The whole of Skagit Bay will before many centuries have passed become tide-marsh land, high enough to reclaim and cultivate.

Another feature worthy of attention is the different heights to which

the tides rise. Every twenty-four hours there is a full tide and a half tide. When the high tide is about sunrise there may be another as high about sunset; otherwise there is one short run out and one short run in every twenty-four hours, and one long run out and one long run in during the same time. The fall of the tide at the long run out, after the long run in, is fully double that of the average short run out, and the extreme storm tides rise to a perpendicular height three times as great as the average of the short run in. Probably the smallest run in and out is not over one-fifth of the rise and fall of the long run in and out of the storm tides. The highest tides are in the winter and spring. The problem is further complicated when the highest storm tides coincide with river freshets, and in the river deltas, where are most of the tide-marsh lands, it is difficult to determine how much of the rise is due to tide and how much to river freshet.

It is usual to consider only the difference between the long run in and the long run out, and not to take account of the short runs in or out, or the storm tides, unless they are specially referred to. During winter the short run in and long run out occur at night, and in the day there is the long run in and the short run out. In summer this is reversed.

The long runs in and out increase in altitude and depth all the way up the strait, and up the sound also. At Neah Bay, the entrance to the strait, the difference between high and low water is 6 feet or less; at the mouth of the Snohomish and over the greater part of the sound below the Narrows it is about 12 feet; on Skagit Bay it may be 1 or 2 feet more; above the Narrows it will average 18 and in some places it reaches 20 feet. The height of storm tides depends on the winds, the shore line, freshets, &c. Generally speaking, they do not rise more than 3 feet above the level of ordinary high tides. It is an unusual storm tide, or one combined with a river freshet, that rises more than 2 feet above the level of a full high tide. In some places tides may have risen from storms alone 5 feet above full high tide. Such a condition never extended over any considerable portion of the sound at once, but was confined to long, narrow channels like those of the upper sound.

Excepting near the outlets of the rivers, the delta of the Skagit, &c., the channels are very deep, many of them too deep for anchorage. From the head of the sound to the ocean there is not a rock, shoal, or other obstacle to navigation in the great channels. Skagit Bay, Port Susan Bay, and Padilla Bay are mostly shoal; yet even here, when the shoal water ends, the banks drop suddenly in many places to where the water is too deep for anchorage. The same is true at the mouth of every river and in every bay. When deep water is once reached there are no obstructions outward to the ocean.

While the channels of the sound are so deep, those of the rivers flowing into it are shallow. Navigation is confined almost wholly to light-draught stern-wheel steamers, which go and come on the tide. They are usually about 100 feet in length and measure from 75 to 100 tons bur-

den. On the sound larger steamers do the business between the different points, while the largest ships and ocean steamers are in the ocean trade to and from the sound. The river steamers seldom go more than 20 miles up the rivers, except in freshets, when they go to the foot of the mountains, not in any instance exceeding 80 miles by the channels. Most of the tide-marsh sloughs are bare at low water, but on the tide many are navigable 3 to 5 miles.

The channels of Grey's Harbor and Shoalwater Bay, and the rivers flowing into them, are all deep enough for the largest ships, but the greater part of the bay and harbor is bare at low water. An excellent place to study the phenomena of tidal action over flats, and the "scour" of river channels running through them, is thus afforded.

LANDS AROUND PUGET SOUND—MARSHES AND FLATS.

The sound basin is 150 miles long from the forty-ninth parallel southward to the Chehalis River, and 50 miles wide from the mountains on the east to those on the west. Throughout this region the uplands are from 200 to 300 feet above the sea level. Three-fourths of the uplands are sterile and fit only for pasturage. This embraces the country extending from Tacoma south to the Chehalis River. Over the rest of the sound country fully one-half of the uplands are fertile. The chief obstacle to cultivation is in the excessively large growth of fir and other timber. Grass grows naturally when the timber is removed, and furnishes excellent pasturage.

The soil on the bottoms is generally very rich and of unknown depth. It differs in quality according to the sources whence it came. Some valleys have much sand, in others the soil is nearly all clay, while peat and moss are constituents of fresh-water marshes. Much of the material deposited by the Puyallup is coarse sand. The Stuck River, which crosses from the White and flows into the Puyallup, is only 10 miles long, but its valley is rich in vegetable and animal matter. There is a supposed infusorial earth, in layers several inches thick, between the vegetable and alluvial matter there deposited, that is said to give a strong odor. Mr. Forrest, a settler, relates how blow-flies deposited their eggs in this earth when dug from his ditches. Lime, animal, vegetable, and alluvial matter are mixed in that valley in a natural compost heap. The waters of White River are white from the glacial sediment, largely volcanic ashes from Rainier, while Green River, its principal tributary, is a clear stream. The soil and other characteristics of their valleys differ in like degree. The water of Black River, draining Lake Washington, is black. The Snohomish bottoms are supposed to excel all others for the production of hay. That is partly owing to soil and partly to climate. The farmers on the Stillaguamish claim that their marsh land is heavier and stronger than that around La Conner. It does contain, without a doubt, more clay. On the other hand, it is urged that

the land at La Conner is the best and driest tide-marsh land in the world; that none but the most fertile Skagit sediment ever lodges on their flats, while too much peat is found at Padilla, &c. At Padilla they claim that peat in the soil gives it greater strength, and that such soil improves the longer it is worked. The men of the Samish aver that their marshes are some inches higher than any other tide marshes, and that their location is better and pleasanter than any or all others. All claim that Puget Sound tide marsh is the *best* land in the world, and the river bottoms next.

With the exception of a few fern prairies and the gravelly plains around the head of the sound, the uplands are characterized by a heavy growth of fir. The swales produce alder and maple, and the fresh-water marshes are covered with hardhack and other brush. Cedar, spruce, and hemlock are found on both uplands and bottoms, while fir grows only on uplands or on bottoms traversed by the later glaciers, that is, on glacial drift deposit. On the Nootsack, the Skagit, and Skykomish the finest fir is well up those streams, on bottom land left by the glaciers. Most of the bottoms are covered with maple, alder, and balm or cottonwood. The maple is of several varieties. One is a large tree intermediate between the rock or hard maple and the soft maple of the Eastern States. Another, called vine-maple, seldom exceeds 8 inches in diameter or 50 feet in height. The top or a single limb bends to the ground and takes root and a new shoot starts up, or from one branch lying on the ground fifty or one-hundred shoots may grow, each with its own roots complete. The devil's club, crab-apple, salmon-berry, and vine-maple combined make an underbrush well nigh impenetrable. Yet this brush land is the easiest to clear of all Puget Sound timbered lands, and the best for a poor man to take up.

As the tide lands are approached there is less vine-maple, &c., but more cedar and spruce. The cedar finally gives way to the spruce, and this in turn to the open tide-marsh prairies. These last are covered with a tall, rank, salt-marsh grass, or else with tullies or cat-tails, which grow several feet higher than a man's head, making these marshes difficult and dangerous places to travel over, for there is risk of falling into deep sloughs. The *open* tide marshes seldom extend over 3 miles in a straight line from salt water. Then come the spruce lands, that require diking against tidal overflow, with open patches of ordinary tide marsh. These seldom extend over 6 or 8 miles back from salt water, and above them are tracts of marsh interspersed with ordinary bottom land, not subject to tidal but liable to river overflow. Many of these can be reclaimed by simply ditching, for along some of the rivers the overflow comes only in the winter and does no injury to crops. On other rivers, like the Skagit, an extensive and costly system of diking will be required to protect these marshes from summer overflow.

It is impossible to separate the fresh and salt water marshes by an arbitrary line, as the change is by imperceptible degrees from one into

the other. All marshes which the tide covers at its highest stages are here called tide marshes, while those overflowed by freshets in the streams and rivers are distinguished as river or fresh-water marshes.

The area of the fresh-water marshes of Puget Sound is three or four times as great as that of the open tide marshes. Many of these fresh-water marshes, particularly if formed in swales on the uplands, are a result of dams made by beavers, and hence are called beaver meadows or beaver-dam lands. The value of these fresh-water marshes depends much upon the *time* of the river overflow. The Skagit River drains more high mountains then any other stream on the sound; hence its highest waters may be in mid-summer. Bottom lands on that stream, subject as they are to overflow at any season of the year, must be diked to be fully protected. Much money and labor have already been spent in this work. The summer overflow of the streams is proportional to the amount of water they severally derive from the highest peaks. Thus, White River and the Nootsack are next to the Skagit; then come the Puyallup and the Nisqually. The Snohomish, the Stillaguamish, and the Samish rarely occasion loss of crops by summer overflow. On the Snohomish, within a few years, 15 miles of ditches have been dug for the purpose of reclaiming its fresh-water marshes. No attempts will ever be made there, in all probability, to keep out winter overflow; it is regarded as a benefit rather than an injury.

Tide marshes and *tide flats* are sometimes used as convertible terms. Generally a tide flat is bare at low water but covered deeply at high tide. On the other hand, tide marsh is about the level of a full high tide, and is usually covered with grass or tullies. It is seldom covered more than 2 or 3 feet deep by a storm tide, and is rarely more than 1 foot above the level of an ordinary high tide. On Puget Sound, if it was over 2 feet above the level of an ordinarily high tide, it would probably be covered with timber and class with ordinary bottom land; or it would be spruce or cedar tide marsh, intermediate in character between tide-marsh prairie and ordinary bottom land.

Where an ordinary tide flows over the marshes so as to cover the land more than 3 feet deep, but little grass will grow. Probably less than 1,000 acres of land which an ordinary high tide would cover to a greater depth than 2 feet are now diked on Puget Sound. This does not include slough channels or occasional low places, but refers to the general level of the land reclaimed. On three-fourths of the open tide marshes reclaimed an ordinarily full tide will fill the sloughs and low places bank full and cover the general level of the land less than 1 foot deep, usually not more than 6 inches. A storm tide in summer will seldom cover the lands more than 2 or in winter 3 feet deep.

Tide flats occupy nearly all the area of Grey's Harbor and Shoalwater Bay, and exceed many times the area of the tide marshes around them. On Puget Sound the tide marshes greatly exceed the tide flats in area.

DRIFTS AND JAMS.

Drift-wood is a very important factor in all these rivers. A river channel at its mouth is distinguishable from a tide-marsh slough chiefly by the snags and drift accumulated on the flats on either side of its channel, and extending beyond the grass-covered tide marshes from half a mile to a mile. Spruce trees, limbs, trunks, and roots form the greater part of this drift. Some of these spruce trunks are 8 feet in diameter and 200 feet long, and occasionally a fir 300 feet long or a cedar 10 or 12 feet in diameter and 250 feet long may be seen. The roots of the spruce are long and strong, and hold firmer than other drift; hence a greater proportion of spruce lodges on the flats, while other drift floats out to sea.

The amount of drift which floats down one of these rivers in a freshet is astonishing. It is not unusual, when a river is bank full and the current running 6 miles an hour, to see the channel covered with drift, and the flow kept up twenty-four hours with scarcely a break. Such a flow of drift may be repeated several times in a year on a stream like the Skagit or Snohomish. In the deltas of the rivers are hundreds of miles of old channels choked with drift and abandoned. Many of them have since been filled with sediment, and at the surface show no traces of the channels which formerly existed there. Again, the channels can be traced part of the way only, but show enough to demonstrate where in olden times a river ran. The Skagit has suffered more from jams than any or all other Puget Sound streams, and now its outlet needs to be improved or a total stoppage may ensue, which will do immense damage. About the time of the most rapid extension of diking throughout the Skagit delta the great Skagit jam was cut through, so that its river channels were compelled to float off all this drift from the great jam, besides the annual increase added, and the waters were confined to the channels and not permitted to float over the marsh lands near its mouth. The consequence is that many of these channels and sloughs are stopped with drift, and the water during high freshets finds scant outlet. Much damage from overflow, washing of banks, and breaking of dikes and dams results, and the settlers are compelled to spend much money and labor in keeping these channels open and preventing a total stoppage and tenfold increase of present evils. In fact, the disposal of the enormous amount of drift which flows down these streams is a problem of the utmost importance for the settlers both on the tide marshes and farther up the rivers.

TERRITORIAL AND STATE RIGHTS.

The uplands in Western Washington are not easily cleared, and settlers have taken the marsh lands, which if the country had been open would not have been touched. Washington, as a Territory, has no rights to either flats or marshes. In other Territories it has been customary to

reserve such lands from sale by the United States, and upon the Territory becoming a State to donate them for educational or other public purposes. Excepting around some of the chief centers of commerce on the sound, but few efforts have been made to acquire the tide flats, but settlers have occupied the marshes and obtained titles under United States patents to their lands. More than 125,000 acres of tide lands and probably 400,000 acres of fresh water marshes have been patented to settlers in Western Washington. Should the admission of the Territory be delayed several years longer, it is probable that steps will be taken to secure from Congress a donation to the future State of other lands to replace the marsh lands sold contrary to the custom of the Government. When the marshes are all entered, as they will be in a few years, the aggregate will exceed 1,000,000 acres. The proposed constitution contains a clause guaranteeing titles to all such lands taken up by settlers.

BAKER'S BAY.

The settlements west of the Coast Range are about twenty-five years behind those on the sound in their development; therefore, what may be stated concerning the undeveloped condition of the coast country should not be considered as implying a want of fertile soil or other resources. Its isolation has thus far delayed its development. The tide lands there are probably as fertile and as easily reclaimed as those of the sound.

Baker's Bay is the roadstead for the ocean commerce of the Columbia River.

Wallicut River before it enters the bay expands into a wide slough. The tide lands in that vicinity amount to about 1,650 acres, of which John Hunter has diked 20 acres. The rest is undiked and used only for pasturage. About 200 cattle get most of their living from this land. It can all be profitably reclaimed.

Chenook River is in size and importance about equal to the Wallicut. Each has been settled over thirty years. The total of tide lands on or near the Chenook is about 1,475 acres, all unimproved but a tract of 75 acres which was diked by H. S. Gile five years ago. About 200 cattle pasture on the unimproved marsh, all of which is the best of land and may be reclaimed at a reasonable expense.

Besides these two there are no other considerable tracts of reclaimable tide marsh on Baker's Bay within the limits of Washington Territory.

The town of Ilwaco is at the head of the bay. Chenook Village, the headquarters of the Chenook Indian tribe, now a small remnant, stood near the east shore. The Chenook jargon is the language of this tribe, with French, Spanish, English, Chinese, and other words and phrases added. These are often corrupted in pronunciation and meaning, but through the influence of the old Hudson Bay Company, and the neces-

sity for a common language, this medley has been familiarized by use, and is now the usual means of communication between whites and Indians, as well as between Indians of different tribes, throughout the Pacific coast region north of California.

SHOALWATER BAY.

The oysters in Shoalwater Bay began to attract attention in 1850, and the first shipment was made in 1851. For over thirty years 50,000 bushels of oysters have been shipped yearly to San Francisco alone. In all nearly or quite 2,000,000 bushels have been shipped since 1851.

Besides the oyster trade the leading business around the bay has been the raising of cattle and sheep. Snow seldom falls deep enough to prevent cattle pasturing, and although good husbandry would require feeding in winter, it is rarely done, and little land is cultivated. Off from the Willopa the land in actual cultivation in Pacific County is less than 2,000 acres. The leading sheep and cattle men own from 400 to 1,000 acres each, and keep from 40 to 125 cattle or 100 to 700 sheep.

Shoalwater Bay is 25 miles long and 6 miles wide. The peninsula which separates Shoalwater Bay from the ocean is about 1½ miles wide. Its northernmost extremity, called Leadbetter's Point, is 27 miles from Cape Hancock. This peninsula contains about 36 sections of land, of which fully 10 sections are beaver marsh, above tidal overflow. All of this could be, while very little of it has been, reclaimed. Only one-fourth of this peninsula is covered with timber, and, where not marshy, most of it has a light sandy soil. The ocean beach is sandy.

Oysterville, the county seat of Pacific County, is situated on the peninsula. West and south of Shoalwater Bay are 1,640 acres of open tide marsh, all undiked and used only for pasturage.

On Bear River, a small stream which flows into the southeast corner of the bay, are tide lands amounting to 970 acres. The towns on the east side are Bruceport and Bay Centre. Between Bear River, at the southeast corner, and the Willopa, at the northeast, are the Naselle, Nama, Bone, and Palix Rivers. These are small streams, with wide and deep channels where they run through the tide marshes.

George A. Smith, of Bear River, has about 100 acres of diked marsh, the only considerable tract of reclaimed land around Shoalwater Bay.

On the Bone and Palix Rivers are 2,500 acres unreclaimed, and 5,000 acres on the Naselle and Nama and at other points on "South Bay," (which includes the southern two-thirds of Shoalwater Bay), a total of 10,000 acres of tide marsh, of which 8,000 acres may be classed as open marsh and the remainder spruce tide marsh. There are great areas of the latter on the east side of the bay, subject to overflow by the highest storm tides, not included in this estimate.

The Willopa River is the principal stream flowing into Shoalwater Bay. It is about 50 miles long, and is navigable for deep-water ships several miles from its mouth.

The "South Bend" saw-mill, on the Willopa, was built about 1868. Up to January, 1881, its total cut was 50,000,000 feet of lumber. In 1882 it cut 13,000,000 feet and in 1883 14,000,000 feet, making the total product since 1868 77,000,000 feet. The spruce on the Willopa is very fine, and this mill cuts a greater percentage of spruce than any other mill in Washington Territory. Most of its lumber is shipped to San Francisco.

Above the tide lands on the Willopa are thousands of acres of excellent river bottom and many good farms in cultivation. There are also beautiful prairies in this valley, nearly all of which are owned and cultivated.

Of the 8,000 acres of tide marsh on the Willopa much has been taken up recently, and considerable areas of it may be diked within two years. It is used now only for pasturage, and perhaps less than one-fourth even in that way.

West of the mouth of the Willopa, on the north side of Shoalwater Bay, are two rivers, named Cedar and North. On these streams, and near to Toke's Point, the northern cape at the ocean entrance, are 2,000 acres of tide marsh, all uncultivated.

This closes the survey of Shoalwater Bay tide lands. They amount to 15,000 acres of first-class, open, reclaimable tide marsh and 5,000 acres of spruce tide marsh. Where for sale, these lands might be purchased at from $5 to $10 per acre. They can be reclaimed as easily, and will be as valuable when reclaimed, as Puget Sound tide lands.

GREY'S HARBOR.

Agricultural improvements are, if possible, less advanced around Grey's Harbor than on Shoalwater Bay. Most of the valuable lands directly on Grey's Harbor have been owned for twenty years or more. The few settlers there had larger farms than those on Shoalwater Bay. Each of them sought to own all the land included in a given valley or range bounded by salt water, a river, and impenetrable upland forests, so that fencing would be unnecessary. Two or three years ago, on all the lands around the harbor some 1,200 cattle were pastured and less than 500 acres were in cultivation.

Peterson's Point is at the south side of the entrance to Grey's Harbor. Hoquium is near the mouth of the Hoquium River, on the east side of Grey's Harbor, 18 miles from Peterson's Point. Four miles farther is the mouth of the Wishkah. Thence 2 miles eastward is Cosmopolis, on the south bank of the Chehalis River, near its mouth. Montesano is 10 miles farther up the Chehalis. Ocean ships go up the Chehalis to Montesano. Having abundant natural resources to back them, Montesano and Cosmopolis should become places of great commercial importance. Above Montesano, in Lewis and adjoining counties, are many large and prosperous settlements in the valley of the Chehalis, which do not come within the scope of this article.

On the south side of Grey's Harbor are Elk Creek, with 600 acres of tide marsh; John's Creek, with 2,000 acres; Redman's Creek, with 1,000

acres; and O'Larry's, Nuskah's, Metcalf's, and Joe's Creeks with 25,000 acres. No diking has been done, but it is expected that large tracts on the harbor and Chehalis River will be diked the present year.

On the main Chehalis tide marshes are found nearly as far up as Montesano. Their amount is probably over 20,000 acres, equally divided between open and spruce tide marsh. All of this is unimproved, and but a small part is used even for pasturage.

Many large streams flow into the Chehalis and Grey's Harbor from the north, which drain nearly half of the country between the Chehalis and the Strait of Fuca.

The Satsop flows into the Chehalis just above Montesano. It is about 80 miles long, and in winter light-draught steamers could ascend it 20 miles. The Wynoochee flows into the Chehalis just below Montesano. It is nearly 120 miles long, and is navigable 35 miles, most of the year, for light-draught steamers. In freshets it can be navigated 50 miles, to the "Big Cañon." Excellent bottom land extends up this stream to this cañon. This is the largest tributary of the Chehalis. There are no tide lands on either the Satsop or the Wynoochee.

Near the mouth of the Chehalis the Wishkah flows into the harbor. This stream is 100 miles long, and is navigable on the tide 15 miles, to its forks. Open tide and spruce marsh extend 8 or 10 miles from the mouth, and are followed by beautiful and productive bottoms, reaching to the forks. Most of the bottom land has been taken up by settlers, who have from 5 to 40 acres each in cultivation. On this stream are about 3,000 acres of open marsh and 4,000 acres of spruce marsh. Fry's Creek, between the Wishkah and the Hoquium, has 1,000 acres of open marsh and as much spruce tide marsh.

The Hoquium forks within 2½ miles of its mouth, but is navigable on the tide for 10 miles. Around its mouth and on its branches are 5,500 acres of open marsh and 2,500 acres of spruce tide marsh. Next west of the Hoquium is Grass Greek, with 1,000 acres of open marsh and 500 acres of spruce tide marsh.

The Humptulups is the westernmost river flowing into the north side of Grey's Harbor. It is about 100 miles long, and in winter can be navigated by light-draught steamers for 25 miles. There are large tracts of bottom land and nearly 5,000 acres of prairie on the Humptulups, besides 2,500 acres of open tide marsh and 3,000 acres of spruce tide marsh.

North of and near the entrance to Grey's Harbor are 500 acres of open tide marsh.

This completes the survey, showing in round numbers 30,000 acres of open tide marsh and 24,000 acres of spruce tide marsh on and around Grey's Harbor and Chehalis River.

Perhaps there is not over 20,000 acres of tide-marsh prairie in all this region that has not scattering spruce timber on it; but 10,000 acres more are comparatively free from timber, and would not be costly to

clear. Grey's Harbor and the Lower Chehalis show many signs of improvement and progress. In 1880 a salmon-cannery was built on the Wishkah, which employs about sixty men during the canning season. Another was operated at Cosmopolis in 1883, which employed fifty men. A saw-mill built on the Hoquium in 1882 had cut 10,000,000 feet of lumber up to January 1, 1884. Its present capacity is 75,000 feet per day.

At Cosmopolis a mill was started in September, 1883, and by January 1, 1884, had cut 1,000,000 feet of lumber. Its capacity is 30,000 feet per day. On the Wishkah a mill of 40,000 feet daily capacity is in process of construction. On Shafer's Island, near Peterson's Point, is a mill with a capacity of 40,000 feet, now ready to begin sawing.

The Hoquium Mill Company owns large tracts of timber and tide lands. In the spring of 1883 they made 200 rods of dike, but inclosed no ground. They may inclose 160 acres this year. Their dike, only 2 feet high and 5 feet wide at the base, is intended to keep out the highest storm tides, but may prove inadequate. Settlers usually begin with dikes too low and narrow, and are forced to build them higher, wider, and stronger. Should such a dike afford as complete protection as one 3½ feet high on Puget Sound, the cost of diking will be less than half as great as on the sound.

No tide lands have yet been inclosed by dikes on Grey's Harbor, but all may be reclaimed, except some tracts near the entrance, where the sediment of which the marshes are composed is not deep and rests on quicksand. There is not a great amount of this kind of land.

The starting of other industries and the resulting influx of people will soon cause the large unimproved places on Grey's Harbor to be subdivided and the tide lands there will be improved.

THE OCEAN COAST NORTH OF GREY'S HARBOR.

The tide marshes on this portion of the coast may amount to 20,000 acres. They are mainly on the Quillente, and included in Indian reservations. None are diked or otherwise improved.

The only settlement in this region is on the Quillente, 35 miles south of Cape Flattery. The river, which divides into several branches, drains a fertile country. Considerable tracts of tide land are found at its mouth, and fine bottoms and forests of fir and other timber farther back. The Quillente prairies first attracted settlers into that region. They contain about 15,000 acres of very fertile land.

Between Grey's Harbor and the Strait of Fuca is a belt of country 30 miles wide by 90 long, full of resources, with probably 100,000 acres of fertile prairie, which some day will be opened by a railroad from Ilwaco to the strait. This region west of the Coast Range will be as productive and valuable as that now being developed between the Cascade Mountains and the waters of Puget Sound.

In 1868 a party of men cut a road or trail from Pysht River, on the

Strait of Fuca, to the Quillente, and another also connecting this settlement with the strait has been opened since. Aside from these the only outlet is by an occasional sail-vessel or steamer from the imperfect harbor at the mouth of the river, or by canoes up the coast to Neah Bay, or on foot or horseback along the beach at low tide. The old settlers have large numbers of horses, cattle, and sheep, and use improved farm implements. Around this nucleus a large population will gather in the near future.

Half way between the mouth of the Quillente and Makah (or Neah Bay) Indian Reservation is the Indian village of Osett. Three miles back of the town is Osett Lake, which is about 10 miles long. Osett River, the outlet of the lake, is 8 miles long, though at "Yellow Banks," south of the Osett village, the lake approaches within 1 mile of salt water.

Two of the largest tracts of tide marsh in the reservation, on Wyatch Creek and Suez River, contain about 1,500 acres.

This closes the description of the tide lands west of the Coast Range.

THE SOUTH SHORE OF THE STRAIT OF FUCA.

The distance in a direct line from Port Townsend to Neah Bay is 90 or 95 miles; along the beach it is nearly a third greater. From Neah Bay to Clallam Bay, 22 miles, there is no road or trail. The only route, excepting by water, is on the beach at low tide.

Clallam Bay is the best harbor between Neah Bay and Port Angelos, and is well situated to become a place of commercial importance. Perhaps some day it may be the terminus of a railroad from the mouth of the Columbia. A route for a wagon road has been surveyed from the settlements on the Quillente to this place. There is much good land in this vicinity, but no large farms.

Twelve miles east from Clallam Bay is Pysht River, where is found the first considerable body of tide marsh east of Neah Bay.

Outside of the marsh and bottom lands at Pysht River are a few sections of extra heavy timber. Good loggers estimate between 35,000,000 and 40,000,000 feet of merchantable fir logs on 640 acres. In fact, nearly or quite that amount has been cut from some sections, and none is left standing near to the water. Several farms have been opened, and all the tide marsh, about 250 acres, is used for pasturage.

By the trail from the mouth of the Pysht River, over the divide, to settlements on the Quillente, the distance is 30 miles.

From Pysht River 20 miles east is Crescent Bay, where are a dozen families, a logging camp, a school, several farms, and a ledge of excellent limestone. Some 15,000,000 feet of logs have been cut here within twelve years.

Four miles eastward from Crescent Bay is Freshwater Bay, so named because many springs come through the bottom of the bay and the water at the surface is often fresh enough to drink.

From this place the distance is 10 miles to Port Angelos, the best harbor on the American side of the strait.

Port Angelos is nearly opposite Victoria, and is by water 30 miles below Port Townsend and 60 miles from the entrance to the strait. A sand-spit, called Ediz Hook, extends 2 miles into the strait and forms Port Angelos Harbor. Its location seemed so good that it was reserved as a town site. The custom-house for the district of Puget Sound was located there in the spring of 1862, and within eighteen months thereafter a population of about 200 people had gathered. About Christmas of the year 1863 a small creek which empties into the head of the harbor rose suddenly and the custom-house and several other buildings were swept into the bay. This sudden rise was caused by the breaking of a natural dam in the mountains south of the town. Five or six years after the flood the custom-house was moved back to Port Townsend, and Angelos dwindled, until now not more than a half-dozen families are there, and the former town site is a cultivated farm. At the end of Ediz Hook is a light-house, built in 1864. The prospects of Port Angelos are improving, and with the settlement of the back country it will become an important place.

Good wagon-roads extend from Angelos to Squim Bay, two-thirds of the way to Port Townsend, thence good trails across the peninsula to Port Discovery Bay, connecting there with roads to Port Townsend.

The Dungeness settlement includes all of Clallam County east of Port Angelos, and has a frontage of 20 miles on the Strait of Fuca. A strip averaging 5 miles in width to the foot-hills is fertile land, and there are many fertile valleys in the foot-hills still unsettled. The level land comprises prairie, some tide marsh, and a great deal of bottom land that needs only to be cleared to make fine farms. The open land in this vicinity was taken up over thirty years ago, and farming is almost the only business.

Dungeness, the county seat of Clallam County, has a population of about 100 people. Dungeness Spit extends 4 or 5 miles out into the strait. The tall light-house on the end of this spit is a very prominent object as seen in passing up or down the strait. The entrance to Dungeness Harbor is obstructed by shoals, so that few large vessels call there. Dungeness River flows into the strait east of the harbor.

There are several hundred acres of tide marsh around the mouth of the river. Capt. E. H. McAlmond has a tract of 60 or 70 acres, kept most of the time in grass for hay. This is the only considerable tract of diked marsh on the strait.

The following is a summary of the average annual products of the Dungeness settlement:

	Bushels.
Wheat	25,000
Oats	10,000
Barley	5,000
Potatoes	50,000
Peas	2,000

Upwards of 1,000 beef cattle are sold annually, and many hogs. About 500 sheep are kept in the settlement, and there are many fine dairy farms.

Squim Bay, which forms the eastern boundary of the Dungeness settlement, is a land-locked harbor 5 miles long by 2 wide. It is not used for any purpose. At its head is a small tract of tide marsh and some fertile bottom land, all uncultivated.

Four or five miles east of Squim is Port Discovery Bay, the most perfectly land-locked harbor in Western Washington. It is upwards of 2 miles wide and 9 miles long. Right in front, but about 2 miles north of its entrance, is Protection Island, which gives security to the harbor, yet leaves it perfectly accessible to the largest ocean ships. The Port Discovery Mill Company does most of the business on this harbor. The mill began sawing in 1859, and has cut about 300,000,000 feet of lumber and 200,000,000 lath. There are several small farms on the bay and some unimproved tide marsh. One agricultural settlement extends from near the head of the bay across the country to the head of Quilicine Bay, the northernmost extension of Hood's Canal. The peninsula between Port Townsend Harbor and Port Discovery Bay is all owned and settled, excepting military or other reservations.

Port Townsend is a prosperous place of 1,500 or 2,000 inhabitants, and the port of entry for the Puget Sound district. Back from Port Townsend is the thriving settlement of Chimacum, celebrated for the quality and amount of its dairy products and for the bog iron ore found there.

From Port Townsend to the entrance of Hood's Canal are several small tracts of tide marsh, all unimproved and none worthy of special description.

THE LUMBER INTEREST.

The controlling interest on the west side of Puget Sound is the manufacture of lumber. The two largest mills on the sound are at Port Ludlow and Port Blakely. Their capacity is fully 200,000 feet for each mill in twelve hours. Most of the large mill companies have experienced men in the woods, and no means are left untried to secure title to the choicest timber lands. During each of the last five years fully 100,000 acres of the best timber lands in Washington Territory have been acquired by these companies. From the land held by a half-dozen companies 30,000,000,000 feet of saw-logs could be cut.

The first shipment was in or about 1851. There was cut prior to 1860, on Puget Sound, about 500,000,000 feet; between 1860 and 1870 the total cut was about 1,500,000,000 feet; from 1870 to 1880, 2,000,000,000 feet; and from the 1st of January, 1880, to the 1st of January, 1884, about 2,000,000,000 feet; that is, in thirty-three years, fully 6,000,000,000 feet. Until 1870 the milling interest far exceeded all others in importance, but agriculture and coal-mining promise to equal it in value soon.

Most of the timber cut prior to 1870 was on Government land. No

real effort was made to stop this practice before that date, and only since 1875 have the laws been strictly enforced. Probably nearly a half of all the timber cut on Puget Sound has been taken from Government land.

HOOD'S CANAL.

The mill companies control Hood's Canal, and everything is subordinated to their interests. Since 1852, 1,000,000,000 feet of logs have been cut there, and still few loggers go more than a mile from the water for their logs. The saw-mills and logging camps are the farmers' markets, and no effort is made to raise anything that will not be used by them. There are agricultural settlements at the head of Quilicine Bay and on the Skokomish River, and many good farms at intervals along the shores of Hood's Canal. On the Docewallups, the Huma-Huma, the Lillewaup, the Duak-a-bush, the Ya-ho-ya, and at the head of the canal are tracts of fertile land, and one or more well-improved farms at each place. In the vicinity of Seabeck and between there and Port Gamble are several well-improved farms. Agricultural settlements also extend 12 or more miles up the Skokomish, which is the chief river flowing into Hood's Canal.

Eight sections of the best bottom and tide lands on the Skokomish River are included in the Skokomish Indian Reservation. The Indians have many cattle and horses, and their tide marsh is used only for pasturage.

By including the marshes of Port Gamble Harbor and all northward to and around Port Townsend Harbor with those of Hood's Canal a total of 2,000 acres might be found. None of this is diked or cultivated, but nearly all is utilized for pasturage in connection with other lands.

WEST SIDE OF THE SOUND.

After passing Foulweather Bluff, just south o f the entra e to Port Gamble Bay and Hood's Canal, the first tract of tide marsh is near the Point-no-Point light, where a few acres have been diked. South of Point-no-Point is Appletree Cove, where Charles Richards has about 18 acres of diked marsh. Probably all the tide marsh from Foulweather Bluff to Port Madison Indian Reservation would amount to 200 acres.

South of this reservation is Bainbridge Island, on which are some good farms. Connecting with the inside passage, west of Bainbridge Island, are Dog-Fish Bay, Port Washington, and Port Orchard. This is a secluded region, with few settlers. Logging, shingle-making, and fishing occupy more attention than farming. In all this section, including Bainbridge Island, there are not more than 500 acres of tide marsh, and none of it is diked or used except for pasturage.

From Bainbridge Island southward to the Narrows there may be 300 acres of tide marsh. The total area of such land, from the entrance of Hood's Canal to the Narrows, on the west side of the sound, does not exceed 1,000 acres, and only two lots, amounting to 25 acres, are diked.

Above the Narrows are numerous islands, small bays, and many channels, but no large tracts of tide lands west of the main channel. Six hundred acres would include all. About 30 acres are diked, but less than 20 are in successful cultivation. David Shelton's tract on Big Skookum Bay is the largest diked tract in this region About 1871 he inclosed 6 acres by a dike 60 rods long, 7½ feet wide at the base, and from 2 to 5 feet high, at a cost of $100. For some years this tract has been in alsike clover and timothy, yielding 12 tons of hay annually. On the same ground is his orchard of 160 pear, 20 cherry, 20 plum, and 20 apple trees. These were planted eleven years ago. For some years his average yield has been of pears 700 bushels, cherries 15 bushels, plums 1,000 pounds, and apples about 100 bushels. The total value of his fruit annually is from $800 to $1,000.

In 1883 Mr. Shelton inclosed 12 acres more with a dike about 75 rods long and 3½ feet high, by 7½ feet at the base. For a distance of 30 rods it extends across a low sag, and is 15 feet at the base by 7 feet high. The cost of this dike was $250.

LANDS ON THE NISQUALLY AND PUYALLUP.

The "Nisqually Bottoms" contain about 7,000 acres, of which 1,000 are in the Nisqually Indian Reservation. There are no spruce bottoms on the Nisqually, but about 1,000 acres now or formerly covered with fir. Around the whole upper sound the best of the fir within 2 miles of salt water has been cut. On the Nisqually not over 15,000,000 feet of fir have been cut, and most of this was on upland.

Washington Hartman has 15 acres of diked marsh, from 4 acres of which an annual yield of 4 tons of timothy hay per acre is reported.

George D. Shannon has 50 acres protected by a dike 175 rods long, 6 feet wide at the base, 3 feet high, and 2 feet wide at the top. Four small sloughs were dammed, and the whole cost of diking was $400. The dike was made in 1874. Mr. Shannon reports 80 bushels per acre as an average yield of oats, and 60 to 65 bushels of barley.

Tide marshes vary greatly in the character, amount, and value of their product when in a wild state. On some the wild grass is worth little for pasturage and nothing for hay, while on others it approximates closely in value to tame grass produced on diked or other improved land. The best wild grass is a fine-blade bunch-grass, which looks like orchard grass or timothy before they head out. This marsh grass keeps green all summer. Daniel M. Mounts has 200 acres of tide marsh mainly set with this grass, which he considers equal if not superior to timothy for hay and pasturage. He has also a large area of gravelly prairie, which he uses exclusively for pasturage. He keeps from 80 to 100 cattle, which during eight months of the year get two-thirds of their living from his wild tide-marsh pasturage. During the winter months they also get much feed on the marshes. The marsh grass starts about two

weeks earlier than the grass on the high, gravelly prairie, and by the middle of March affords good pasturage. The cattle feed on the marsh during the daytime and range in the timber and on the prairie at night. They do much better than they would if confined to either. Cattle well cared for during the winter will fatten on this marsh pasturage in the spring, before the winter price of beef cattle falls. Mr. Mounts usually turns off from 10 to 12 grass-fed cattle each spring, at winter prices for stall-fed cattle.

The total area of tide lands on the Nisqually River is 3,357 acres, of which only about 70 acres have been reclaimed.

The Puyallup River flows into Commencement Bay, which is the head of Admiralty Inlet and the harbor of Tacoma, the terminus of the Northern Pacific Railroad. The lower portion of the Puyallup Valley, with nearly all of the tide marshes, is included in the Puyallup Indian Reservation. Not over 300 acres of this land is off the reservation, and this is under the control of the railroad company and will never be used for agricultural purposes.

South of the Puyallup River the total area of tide marsh is about 500 acres, 200 acres being in a reservation and 300 acres controlled by the railroad company. The school farm for the Indians is on the reservation tide marsh, of which 60 or 70 acres have been diked. The rest is used for pasturage. North of the Puyallup is a tract of about 2,000 acres of unreclaimed tide marsh, all on the Indian reservation.

KING COUNTY.

The tide lands in King County are mainly on the Duwamish River, which flows into Elliott's Bay, or, as it is otherwise called, "Seattle Harbor." These lands are on both sides of the river and within 5 miles of the city of Seattle. Property within 10 miles of either Seattle or Tacoma has a speculative value. The whole Duwamish Valley is subject to this speculative influence, which has so far not injured that settlement, but rather made the people more careful of their homes, eager to improve, and unwilling to sell. There is very little land in the Duwamish Valley for sale.

Starting from the Northern Pacific Railroad, nearly 20 miles south of Tacoma, the extension runs northward, crossing the Puyallup 10 miles east of Tacoma, and thence through the Stuck Valley to the White River Valley, and down that valley and the whole length of the Duwamish River Valley to Seattle. The road extends through a very fertile region, that is well settled and carefully cultivated. It is noted for its hops, dairy products, fruits, vegetables, hay, and grain. The tide lands at the mouth of the Duwamish form only a narrow fringe, and are less improved and far less thoroughly cultivated than the bottom lands above them.

About 250 acres, or one-half, of the marsh land west of the river is diked, most of which is in meadow or under cultivation.

In 1883 Mr. McCallister made 160 tons of hay on 70 acres. Mr. Maryott reports that in 1883 he made on 40 acres of tide marsh 160 tons of hay, and in 1882 he cut an equal amount from the same ground. He claims to have single acres of tide marsh that will yield 5 tons of cured timothy hay at a single cutting.

East of the river nearly all the open marsh is diked and in meadow.

Ladd & Tilton from 120 acres cut 300 tons of timothy hay, and there are portions of the meadow which will yield 4 tons per acre at each cutting. This tract was reclaimed by a dike 300 rods long. One hundred rods of the dike is 14 feet at the base, 5 feet high, and 8 feet wide at the top, and cost $1,000. There are five small slough dams included in this estimate, which cost $100. The cost of diking east of the Duwamish has been, for 740 rods, $3,400. West of the river 2 miles of dike cost $2,000. On both sides of the river something over 4 miles of dike, inclosing about 450 acres, cost $5,400.

At the mouth of the Duwamish River are several tide-marsh islands. On one of these a dike 400 rods long, which cost $2,800, and $300 extra for the dams to six sloughs, incloses 65 acres. This dike was built in 1878. Large crops of grain have been raised, and in 1883 the first cutting of grass from 60 acres made 165 tons of hay.

The tide lands on the Duwamish River do not exceed 1,000 acres. Of this amount over 500 acres are inclosed by 5½ miles of dikes, which cost about $8,500.

Smith's Cove is on the north side of Seattle Harbor and 3 miles distant from Seattle. All the tide marsh on this cove was diked in 1877. In front of the marsh is a sand spit across the head of the cove. The sand blown up on the edge of the marsh was used to build the dike, which was supported on the inside by cedar lagging driven into the marsh. This dike, which is 4 feet high, 10 feet wide at the base, and 4 feet at the top, with a ditch outside in the sand, has stood seven years. It is about a half mile long, and cost $300. A slough dam cost $100 extra, making the total cost $400. The tract inclosed contains about 50 acres.

This ground was seeded to grass after burning off the dead wild grass in the spring. The seed "caught," and since that time over 3 tons per acre of hay have been made yearly on the 25 to 30 acres kept for meadow. Ten acres of this marsh in pasture afford ample feed for 15 milch cows, keeping them in good condition, with a full flow of milk, from April 1 to December. During the remainder of the year they get half of their feed from the same land. Usually the marsh keeps green the year round. The tame grasses killed all wild grass and weeds, and the hay commands the highest market price. Sixty bushels of wheat and nearly 100 bushels of oats per acre have been raised on this marsh.

On Salmon Bay, north of Seattle Harbor, and on the sound north and south of the entrance to the bay, are undiked tide lands amounting to 150 acres.

The totals for King County are as follows: On Duwamish River, 1,000 acres, over a half of it diked; elsewhere in the county, 250 acres, one-fifth of it diked; total diked, 550 acres. Length of dikes, 6 miles. Cost of dikes, $9,000.

SNOHOMISH COUNTY.

At Twelve-Mile Point, near the King County line, is a tide marsh of nearly 100 acres. This has been partially reclaimed, but never cultivated, and is now used only for pasturage. At Ten-Mile Point is an unimproved marsh of similar area. After this there are no considerable tracts of tide marsh south of Point Elliott, on which Mukilteo is situated. Here is a tract of 50 acres which has been imperfectly diked. It is divided into small tracts, and the productions are mainly hay and vegetables. Mukilteo is 7 miles from the mouth of the Snohomish River and 12 miles north of the southern boundary of Snohomish County. At one time it had promise of importance, but now is only a fishing station and a place for steamboats passing east of Whidby Island to take in wood and water. Perhaps more salmon are caught here than at any other point around Puget Sound. In the fishing season many men are employed, but during the rest of the year the population does not exceed 100.

The tide lands south of the Snohomish Valley in King County do not exceed 250 acres, of which 200 acres are unreclaimed.

On the Snohomish is the greatest amount of unreclaimed tide land to be found at any one place on Puget Sound. The logging industry has carried settlements *up* the river, and hundreds of farms have been cleared out of heavy timber, while the tide marshes have been allowed to lie unimproved or to fall into the hands of speculators.

The Snohomish near its mouth divides into crooked channels, which are connected by cross channels, forming islands in the delta. The main channels converge but do not all meet, some flowing into Priest Point Bay, which opens towards the south or southwest. Ebey Slough, the first channel to branch off from the main river, is 25 miles long, while a straight line from its head to its outlet is only 6 miles. On the main river, 1 mile below the head of Ebey Slough, is the town of Lowell. From Lowell a fresh-water marsh extends 8 miles in a southeast direction. The main portion of this marsh is south of Snohomish City and on the opposite side of the river. In some places it approaches to within a few rods of the river, while at others it is a half mile or more back. This marsh contains 10,000 acres and is nearly all held by settlers. Some 10 miles of ditches and canals have been dug, but none of it will be diked.

On the south side of the main river are tide marshes amounting to 1,000 acres, equally divided between open and spruce marsh. At Preston's Point, at the mouth of the river, a tract of 50 acres has been imperfectly diked. The tide lands of the delta additional to the above

are about 5,200 acres open and 1,775 acres spruce. The timber on 1,000 acres of this spruce marsh will not seriously increase the cost of reclaiming. We have a total, then, in round numbers, of 8,000 acres of open and spruce tide marsh in the delta of the Snohomish and on the south side of the main river.

A few years ago large tracts within the delta were said to be under contract to be diked, and were sold by speculators at an immense advance. It is found that all the talk of diking was simply an advertisement, and that no lands were diked or inclosed under the alleged contracts.

Dr. H. A. Smith settled on Smith's Island, in the delta, in 1864. In that year and the following he inclosed 65 acres by a dike of 10 feet base, 4 feet high, 2 feet wide on top, and about 1½ miles long. This dike cost him $2.50 per rod, besides $50 for slough dam and tide-gate, a total of $1,250. In the spring of 1865 he began cultivating the ground, set out an orchard, sowed grass seed, &c. The trees were free from moss and bore abundantly. Rutabagas, mangel wurtzels, turnips, cabbage, cauliflowers, carrots, parsnips, rhubarb, asparagus &c., all flourished. Potatoes planted in drills and covered only with straw and barn-yard refuse yielded an excellent crop. In the spring of 1865 all the old sod remaining was burned over, and, without plowing or harrowing, timothy, clover, and red-top were sown, and after the first season he cut 3 tons of hay to the acre. Everything went forward successfully as long as Dr. Smith remained on the place. In 1870 other engagements took him away and he never returned. The tide-gates became choked and the land flooded. Grass and trees were soon ruined, and finally in 1877 the dike burst. A portion of the dike was sodded with turf inside and out when built. The unsodded part is still as good as ever, while that which was sodded became a harbor for field-mice, that honeycombed the dike until it was easily broken.

The abandonment of Smith's place has given rise to doubt in regard to the value of Snohomish tide marshes, but Smith's improvements were successful as long as he looked after the place, and things went back only as a consequence of neglect. Diked marshes require constant attention, and suffer more than other lands from even temporary neglect. The Snohomish tide lands are equal to any other tide lands on Puget Sound, and when settlers supplant the speculators who now hold them there will be no cause to complain of them.

Between the main river and Union Slough, above the cut-off which connects them, a tract of 40 acres has been diked. The dike is 320 rods long, 7 feet wide at the base, and 3 feet high, and cost, including slough dams, $2.50 per rod. Within eighteen months nearly all the vacant land in that vicinity has been located by settlers.

Between Union Slough and Steamboat Slough are two tracts of diked land, amounting to 130 acres. One of these, containing 60 acres, is protected by a dike 400 rods long, 4 feet high, 9 feet wide at the base,

and 3 feet on top, which cost $1,200. In 1883, 20 acres of this tract produced 80 tons of oat hay and 8 acres gave 30 tons of timothy hay. The other tract, containing about 70 acres, was diked eight years ago. The dike is 3½ feet high, 8 feet at the base, and a mile and a half in length, and cost $1,500. For several years this place was well cared for, and yielded abundant crops of oats, wheat, and hay. Now no one lives on it, the tide gates and boxes are choked, and salt water has killed most of the tame grass.

Between Steamboat Slough and the main river 235 acres, in different tracts, are inclosed by dikes 5½ miles long, which cost $4,750. It would require $2,500 to put all these dikes in good condition.

On McAllister's Island most of the tide land contains peat, with more sand and less clay than the Stillaguamish Flats. The water which floods the island is very rarely even brackish. The tides cover only the lowest places. About 2,500 acres of this island is open prairie, on which a red-top grass grows from 3 to 7 feet high. Some of the lower places are covered with flat grass. By making "blue-joint" hay, and providing places to keep cattle out of the water during the winter freshets, 1,000 head could be kept there the whole year. No one has attempted this, because of the winter freshets, which cover some parts of the island very deep. Most of the land on this island is better adapted for stock than for grain. The straw would grow too rank and lodge more than on the regular salt marsh or ordinary river bottom land. Lime is the only fertilizer needed there, and *it* could scarcely increase the quantity produced, but would in many cases improve the quality. There are many limestone quarries and kilns at different places on Puget Sound, and refuse lime costs but little besides the expense incident to transporting it. One dressing of lime will rot the peat as much as five or six years of cultivation. On McAllister's Island three lots amounting to 31 acres are protected by 530 rods of dike, which cost $1,840. In 1884 McAllister & Sons hope to dike 300 acres of land. This will require 700 rods of dike, which will be 12 feet wide at the base and 4 feet high, and will cost $2,500, and 300 rods more along the river bank, which will cost $1 per rod. Four hundred dollars more will be required for slough dams. The total expense anticipated in diking 300 acres is $3,200. Possibly others may spend as much in diking on that island during 1884.

The Snohomish Delta, between the main river channel and Ebey Slough, contains about 7,000 acres of tide marsh, of which all but 1,000 acres is nearly free from timber. To reclaim 266 acres of the delta, in small parcels, over 7 miles of dikes have been constructed, at a cost of $6,700. An additional expenditure of $2,000 would be required to put all these dikes in good repair. The 7,000 acres of tide lands in the delta would require for their protection, under one management, 40 miles of dikes, which would cost $50,000. Without concerted action

the length of dikes would be doubled, and their cost increased in a much greater ratio.

Ebey Slough is so crooked that tide lands on the right bank are found south, east, and north of the slough. From its head to Priest Point, on the right bank, is a total of about 3,500 acres of tide marsh, of which 2,000 acres are free from timber, or nearly so. Out of this whole body 52 acres are inclosed by dikes 1½ miles long, which cost $950. The total area of tide marsh in the Snohomish Valley is about 11,500 acres. Not over 3,000 acres of this is incumbered with sufficient timber to materially increase the cost of reclaiming. To protect all this land 70 miles of dikes would be required. They should be not less than 4 feet high and 9 feet wide at the base, and would cost between $75,000 and $100,000. This supposes concert of action. It will probably be diked a little at a time, by the settlers, who will work independently, build fully 200 miles of dike, and spend a fourth of a million of dollars before it is all inclosed.

The tide marshes of the Snohomish, in comparison with others, have the following advantages: No part of them is more than 2 miles from navigable tide water, and steamboats could receive and discharge freight at every farm. Much of the land requires but little dike, and drainage would never be expensive. Nearly all of it is sheltered from the waves, so there is no surf to destroy the dikes. It is nearly all *fresh-water* marsh, and ready for cultivation as soon as diked. Stock is sheltered from the raw salt breezes and can have fresh river water on every ranch.

At present there is considerable talk of diking, and should those who talk go ahead there may be 1,500 acres diked in 1884.

The Stillaguamish Marshes are next northward. Hatt's Slough cuts across from the Stillaguamish, 6 miles above its mouth, to Port Susan Bay, a distance of 3 miles. On the south side of this slough is a marsh of 600 acres, bounded on the west by Port Susan Bay, south and east by highland, and north by the slough, except where timber lands above tidal overflow intervene. These last are the ordinary river-bottom lands before described.

From the highland back of the marsh many millions of feet of fir logs have been cut within twenty years.

In 1881 Messrs. Adams and Waddington inclosed 30 acres with a dike, in semicircular form, from highland to highland, a distance of 140 rods. The dike is 7 feet at the base, 3 feet high, and 3 feet wide on top, and cost about $2 per rod. Three slough dams cost about $60, making the entire cost $340.

In 1882 Adams had 3 acres in oats, which yielded 350 bushels. In 1883, 5 acres gave 20 tons of oat hay, which was baled and sold to logging camps close by at $16 per ton. In 1883 he raised good crops of beans, potatoes, onions, carrots, peas, and turnips. The onions, carrots,

and beans succeeded best. The same year he cut 4 tons of wild hay from 2 acres of his diked marsh.

James Long has 100 acres inclosed by a dike 300 rods long, 8 feet at the base, 4 feet high, and 3 feet wide on top, which cost $1,000, with $80 extra for slough dams. He estimates his (timothy and clover) hay crop in 1883 at 200 tons from 60 acres.

Jacob Isaacson has 20 acres protected by a dike 160 rods long, 7 feet at the base, and 3½ feet high. In 1881 he had 6 tons of hay from 4 acres, and 360 bushels of oats from an equal area. In 1883 his crops were as follows: Wheat, 3 acres, 175 bushels; barley, 1 acre, 75 bushels; oats, 3 acres, 300 bushels; oat hay, 3 acres, not thrashed, 10 tons; timothy, 6 acres, 25 tons.

Adams and Waddington used earth from the highland adjoining to form their dike, for the reason that the marsh soil contained so much vegetable matter as to make it too light and porous for that purpose. The earth used was a sandy loam, with some gravel and sufficient clay to render it compact and water-proof.

For many years Mr. Adams has noted the tidal level and comparative height of the tide lands from his place northward to the Skagit River. He has been over this region at all stages of the tides, and what he states can be relied upon. Most of what is here noted in reference to this matter was furnished by him.

The tract south of Hatt's Slough is sedimentary clay, mixed with vegetable matter. There is no peat in it. The grass which grows wild here is like that north of the Nisqually and on the Samish Flats, to be hereafter described. It is a hardy grass, which grows some 18 inches high, seeds very thickly, and looks like blue grass. Each summer about 100 cattle and as many sheep get most of their living from this tract. Cattle fatten quicker and hold their flesh later in the fall on this grass than upon tame pasture.

The highest storm tide during the last nineteen years was in January, 1868, when it rose from 14 to 26 inches above Mr. Adams's marsh. The marsh along the shores of Port Susan Bay is from 6 to 12 inches lower.

Of the marsh land in the Stillaguamish Delta, that is, between Hatt's Slough and the Stillaguamish River, that on the north bank of the slough will average from 8 to 12 inches higher than that near the mouth of the main river and towards Stanwood; that on the north bank of the slough is of about the same level as the marsh on Adams's and Long's places. At Stanwood, on the north bank of the Stillaguamish River, and within 1 mile of the mouth of that river, the tide rises nearly 1 foot higher. From 2 to 3 miles north of Stanwood lands are diked which the tide would flow over, were it not for the dike, fully 2 feet deeper than at Stanwood, or 3 feet deeper than at Long's, Adams's, &c.

The Stillaguamish Delta comprises all lands between the main river and Hatt's Slough, amounting to 2,095¾ acres by the United States land surveys. Of this over 1,600 acres may be classed as tide marsh, in-

cluding 400 acres of brush and spruce marsh. There are three grades of land running across the delta—river bottom at the upper end, spruce marsh across the middle, and open tide-marsh prairie on the front. The diking of the tide-marsh prairie shuts off all salt water and leaves nothing but river overflow to contend with. This comes in from back of the tide marsh through the timber. It does not occur while crops are growing, and will not, for some time at least, be excluded; but, as will be seen, it has a strong claim for recognition in all plans for the reclamation of delta marshes. The tide-marsh prairie of the delta is divided into two nearly equal parts by a slough, which at times of high freshets in the Stillaguamish discharges a volume of water into Port Susan Bay nearly equal to that carried by the main channel. In 1879 and 1880 a dam was built across the slough, at a cost of $1,400, which, in connection with a dike 1½ miles long, costing $2.75 per rod, was intended to protect a large tract from salt-water overflow. About $3,000 were invested in dike, dam, and preparation for the first crop, when a freshet carried the dam out and the attempt was abandoned.

The Brawley Brothers, who have secured control of 560 acres lying on either side of the slough, have now undertaken to reclaim their land by carrying their dikes along the slough, on both sides, to a point 100 rods above the site of the old dam, where the slough forks. Here they have constructed dams. It is understood that they will not stop short of success even if they are obliged to continue the dikes on both sides of the slough and abandon the dams altogether.

Their land (520 acres) cost $8,400 and improvements in 1883, $2,000. When the latter are complete, and dwelling, barns, and warehouses erected, the investment will amount to $15,000.

With the Brawley Brothers' dikes and dams completed there will be only 340 acres of undiked tide marsh in the delta, and the area will probably be reduced to 130 acres during 1884.

The following notes have been taken of crops on the diked lands of the delta:

In 1882 T. B. Nealy made 25 tons of hay on 10 acres. The same lot yielded 22 tons in 1883, the season being unusually dry. Potatoes, beets, carrots, &c., produced well.

In 1881 O. S. Matrand harvested 1,220 bushels of oats on 10 acres, 38 bushels of barley on a half acre, and from 4½ acres of timothy, at the first cutting, 24½ tons of hay, and a heavy crop at the second cutting. In 1882 he had 12 acres in oats, which gave 1,200 bushels. In 1883, 3 acres of wheat gave 113 bushels, 1 acre of barley 50 bushels, and 8 acres of oats 1,045 bushels. On 1 acre he made 7 two-horse loads of hay, and he estimates a yield of 30 tons from 6 acres. Mr. Matrand's land is of the best quality and is well diked and drained.

In 1878 Johan Brygger had 600 bushels of oats on 10 acres, 60 bushels of wheat on 4 acres, and 340 bushels of barley on 10 acres. In 1879 the place was in better condition, and he had 600 bushels of oats on 9

acres, 1,000 bushels of barley on 17 acres, 100 bushels of wheat on 10 acres, and 50 tons of hay on 25 acres; in 1880, 1,850 bushels of oats on 27 acres, 30 bushels of barley on 2 acres, 160 bushels of wheat on 17 acres, and 80 tons of hay on 30 acres. In 1881, 53 acres in oats yielded 4,500 bushels and 30 acres in grass gave 90 tons of hay. In 1882 he harvested 4,500 bushels of oats on 77 acres; in 1883, 6,200 bushels of oats on 74 acres and 180 bushels of barley on 3 acres. For some years Brygger's place has suffered from bad drainage and overflow; hence the yield has been irregular.

Besides the tide-marsh land within this delta there are about 125 acres of river-bottom land cleared, and 75 acres more slashed and in process of clearing. Hay is the principal crop. One year with another, the river-bottom land averages about 3 tons per acre, and requires far less attention than tide-marsh land.

At Stanwood the Stillaguamish River divides, one channel flowing nearly due south into Port Susan Bay, the other northwest into Skagit Bay. These channels and Davis's Slough constitute the boundaries of Laque's, sometimes called Iverson's, Island. This island contains about 400 acres, all of it open tide-marsh prairie. Being situate at the mouth of the river, it received so much drift on the lower portion that nearly 100 acres are unfit to be diked. The drift is not only on the surface, but extends down indefinitely, like a jam.

The improved portion, 125 acres, is inclosed by a dike 600 rods long, 8 feet wide at the base, 3½ feet high, and 3 feet wide on the top, which cost $1,340, besides about $280 for dams in eight sloughs. These sloughs were from 3 to 8 feet deep below level of tide marsh, and are from 6 to 20 feet wide. The total cost of dikes, dams, and repairs has been about $1,900 for 121 acres. When most of this dike was built, in 1878 and 1879, average wages for diking were about $1.50 per day and board, but now they are $2 per day and board.

There are eight drainage-boxes now in use. The one in the big slough is 18 inches high by 3 feet wide; the others are only 8 by 12 inches, inside measurement. Under ordinary circumstances they keep all the land under dike free from water. The large boxes clear themselves, while the smaller ones are continually liable to be choked with drift-wood.

In 1877, 3 acres of the island in oats gave 375 bushels. In 1878 the land was flooded and a half mile of dike was destroyed. In 1879, 35 acres in oats yielded 3,300 bushels, 4 acres in barley 240 bushels, and 4 acres in wheat 120 bushels. In 1880, 36 acres in oats gave 2,400 bushels, 4 acres in barley 160 bushels, 7 acres in wheat 150 bushels, 12 acres in timothy 20 tons of hay, and one-fourth of an acre in rye 10 bushels.

In Mr. Laque's opinion, when the land is newly diked the wild hay cut thereon is not more than half as valuable as clover or timothy, but after a number of years the wild grass makes hay nearly or quite as

good as tame hay. The improvement in the quality of the pasture is sufficient to pay the cost of diking for that use only. Timothy and clover sown on wild-grass sod will greatly improve the pasturage, so that in a few years, one acre treated thus will become equal to three acres of wild, undiked pasture. But Laque believes that the land should be plowed before it is attempted to seed it for meadow. On this island it costs over $10 per acre, after diking and ditching, to get off logs and drift and to break up the sod. Some of the land there costs much more than that simply to remove the logs and drift.

The tide lands between the Stillaguamish and the Skagit in Snohomish and Skagit Counties form one continuous tract. In two townships north of the Stillaguamish there are about 3,525 acres of tide marsh, of which 3,000 acres are free from timber and high enough to dike, and 300 acres are covered with spruce or brush. The remainder is too low for profitable diking. East of the town of Stanwood is Record's Slough, which extends to the highland, and into which many million feet of saw-logs have been hauled. On each side of this slough is spruce tide marsh. None of the marsh between Record's Slough and the main river is diked. West of Stanwood, Stillaguamish Slough, about 50 feet wide, runs nearly due north towards the Skagit. Between it and the main river is an island containing 600 acres, of which 150 are diked and 250 more are suitable for diking.

The Stillaguamish Flats include all the lands from Stanwood to the Skagit River, a distance of some 5 miles; but the lands north of the Snohomish County line will be separately described. It is about 4 miles from Stanwood north to the county line. This tract includes about 2,500 acres of tide marsh, most of which is under dike and nearly all free from brush or timber.

An average of good and bad crops on these flats may be taken from the following:

In 1878, on six farms, 305 acres in oats gave 20,428 bushels, nearly 67 bushels per acre; 2,516 bushels of wheat grew on 68 acres, an average of 37 bushels per acre; 4,900 bushels of barley on 81 acres, an average of about 60½ bushels per acre; 375 tons of hay on 133 acres, or nearly 3 tons per acre.

In 1879 no general account of the hay crop was secured. Five farms reported 28,150 bushels of oats on 390 acres, an average of about 72 bushels per acre; 1,850 bushels of wheat on 55 acres, an average of over 33 bushels per acre; and 3,300 bushels of barley on 39 acres, an average of over 84½ bushels per acre.

In 1880 crops were nearer a failure than in any preceding year, and the whole section was not fully reported. Nineteen thousand four hundred bushels of oats were produced on 397 acres, an average of nearly 49 bushels per acre; 1,900 bushels of wheat on 115 acres, an average of over 16½ bushels per acre; 1,700 bushels of barley on 28 acres, an average of nearly 61 bushels per acre; and 225 tons of hay on 77 acres, or

nearly 3 tons per acre. The decreased yield of 1880 was owing to a late and wet spring, by reason of which crops were hurriedly and badly put in, to heavy rains in harvest, and to an overflow of salt water.

Grain had been low for some years, and in 1881 less cultivation was bestowed than usual, the lands were flooded from the river, and crops were poor. From 443 acres in oats 20,000 bushels were saved, 1,500 of barley on 37 acres, 200 of wheat on 10 acres, and 215 tons of hay on 97 acres. The average yield per acre was for oats over 46 bushels, barley over 40½ bushels, wheat 20 bushels, and hay over 2 tons.

In 1882 the crops were 13,550 bushels of oats on 286 acres, 2,740 bushels of barley on 87 acres, and 546 tons of hay on 225 acres. The oats averaged nearly 47½ bushels per acre, the barley 31½ bushels, and the hay nearly 2½ tons per acre.

In 1883, 11,350 bushels of oats were harvested on 273 acres, or over 41 bushels per acre; 900 bushels of barley on 27 acres, an average of 33⅓ bushels per acre; and 631 tons of hay on 235 acres, or nearly 2¾ tons per acre.

One of the most noticeable things in this section is the change from grain to hay since 1880. The decrease in grain and increase in hay, cattle, and area devoted to pasturage are manifest.

In 1880 not over 25 horses, 40 cattle, and 200 hogs were kept south of Moore's Slough. In 1883 the total stock kept was 40 horses, 175 cattle, and 100 hogs.

The southernmost channel of Skagit River is called "Tom Moore's Steamboat Slough." From this a slough deepened and extended southward to the highland is called "Tom Moore's Logging Slough." The mouth of the Steamboat Slough is just north of the Snohomish County line and nearly 5 miles north of Stanwood. All tide lands south and west of Tom Moore's Logging Slough are usually considered as a part of the Stillaguamish Flats. The greater part of this land has been but recently diked and much of it is still uncultivated.

The crops reported in 1878 were 4,300 bushels of oats on 110 acres, or over 39 bushels per acre, and 100 tons of hay on 40 acres, or 2½ tons per acre.

In 1879 there were 6,710 bushels of oats on 155 acres, or 43⅓ bushels per acre; 19 tons of hay on 7 acres, or over 2½ tons per acre; and 813 bushels of wheat on 32 acres, or 25⅓ bushels per acre.

In 1880 there were 6,344 bushels of oats on 155 acres, or 41 bushels per acre; 500 bushels of wheat on 35 acres, or 14⅓ bushels per acre; and 49 tons of hay on 25 acres, or nearly 2 tons per acre.

In 1881 there were 4,100 bushels of oats on 100 acres, or 41 bushels per acre; 200 bushels of wheat on 5 acres, or 40 bushels per acre; and 150 tons of hay on 114 acres, or nearly 1⅓ tons per acre.

In 1882 there were 5,400 bushels of oats on 120 acres, or 45 bushels per acre, and 260 tons of hay on 150 acres, or 1⅜ tons per acre.

In 1883 there were 6,587 bushels of oats on 162 acres, or 40⅓ bushels

per acre, and 400 tons of hay on 230 acres, or nearly 1¾ tons per acre. No crops of barley are reported.

ISLAND COUNTY.

This county is composed of Whidby and Camano Islands, which lie west of Snohomish and Skagit Counties.

Whidby is the largest island in Puget Sound, its area being 104,386 acres. It is about 50 miles long and from 1 to 10 miles wide, and is separated from Fidalgo Island on the north by Deception Pass, while Saratoga Passage separates it from Camano Island on the east. West of this island are the Strait of Fuca and Admiralty Inlet. There are no good harbors on that side of the island, but on its east side all the bays and inlets are used. Holmes's Harbor and Penn's Cove are excellent harbors.

This island was first settled in 1850, but its permanent settlement began in 1851. By 1853 its most available places had all been taken.

The agricultural improvements have been mostly made on the northern part of the island, while hundreds of millions of feet of timber have been logged off the south end. In the vicinity of Penn's Cove and Oak Harbor are many large farms, with excellent orchards and great numbers of sheep and cattle.

On the whole island are about 6,000 acres prairie, 6,000 acres marsh of all kinds, and 2,000 acres cleared timber land. In a single season 150,000 bushels of potatoes have been raised for export to San Francisco, and not far from 30,000 bushels of grain and 5,000 tons of hay are raised annually. Somewhere near 250 horses, 2,000 cattle, 2,000 sheep, and 500 hogs are kept by settlers on the island. Most of the tide marsh is in pasture, or, if diked and improved, in meadow. The largest crops of grain are raised on upland prairie. It was this prairie land which caused the island to be settled before any of the rest of the lower sound.

On the west side of the island, at the entrance to Admiralty Inlet, is Admiralty Head, or Red Bluff. Here is a light house, and east of the light-house is Crockett Lake or Lagoon, a body of water separated by a gravel beach and sand spit from the waters of Admiralty Bay. The lake is quite shoal, and by draining it through a ditch and flume across the natural dike its area has been reduced from 600 to 200 acres. The 400 acres partially drained have been seeded with blue grass and red-top and produce fair crops of hay and abundant pasturage. There are small tracts of tide marsh near the lake and in other parts of the island, all unimproved and requiring no special description.

Camano Island is east of Whidby Island and west of the northern part of Snohomish County. It is about 18 miles long and contains 26,787 acres. The south end of the island is not inhabited. The north end is controlled by the Puget Mill Company, which owns the large

saw-mill at Utsaladdy, where is an excellent harbor. The agricultural settlements are mostly on the east side of the island, near the Stillaguamish. The tide marshes of the island amount to 1,000 acres, but none are diked.

This gives a total of 4,000 acres in Island County, of which only 485 acres are under dike.

SAN JUAN COUNTY.

This county is made up of the disputed islands east of Vancouver's Island which in 1872 were awarded to the United States by the Emperor of Germany. They are bounded by the Gulf of Georgia on the north, the Rosario Strait on the east, the Strait of Fuca on the south, and the Canal De Haro on the west. Prior to the beginning of the dispute, in 1859, they formed a part of Whatcom County, but after its settlement, in 1872, the legislature of Washington Territory formed them into a separate county.

There are in this county sixty islands, of a total area of 104,386 acres, exactly the area of Whidby Island. Thirty-four islands of the group contain less than 5 acres each.

Most of the lime used on Puget Sound is manufactured in this county.

In the whole of San Juan County there are about 600 acres of tide marsh, of which 200 acres have been diked, at a cost of about $2,000.

WHATCOM COUNTY.

In 1883 the legislature subdivided Whatcom County and out of its southern half formed the new county of Skagit, the northern part retaining the name of Whatcom. The greater portion of the tide lands of the old county of Whatcom are within Skagit County. The total of tide marsh in Whatcom County is 4,000 acres, of which 215 acres have been diked.

SKAGIT COUNTY.

The tide lands on the south bank of Skagit River are closely connected with the Stillaguamish lands.

Of the 1,000 acres in this district 700 acres are inclosed by dikes on Richard Holyoke's place. In 1877 he became interested in this tract, and by the end of 1878 had spent $4,000 in diking and over $1,000 in ditching. In 1879 he had 7,000 bushels of oats on 100 acres. In 1880 he had 2,800 bushels on 70 acres. In 1882 the big summer freshet on the Skagit flooded the whole place and destroyed the crop. In 1883 he had 8,000 bushels of oats on 150 acres and 1,500 bushels of barley on 35 acres.

One-third of the diked land in this district was covered with brush, the rest with tullies or cat-tails. The brush land cost fully $20 per acre to grub, break, and prepare for cultivation, but it is better land than

the open marsh, because it is drier and has more vegetable matter mixed with the clay.

At Mount Vernon, some 12 miles by river channel from the mouth of the Skagit, the highland first reaches the river bank. Near this point are 4,000 acres of marsh and 3,000 acres of river-bottom land, and many settlers are clearing farms.

In 1878 five men began diking. Their dike was 8 feet at the base, 2½ feet high, and 3¼ miles long, and cost $1,800. It was completed before 1880, and was supposed to protect 650 acres of land against ordinary river freshets. Since 1881 it has been found wholly unequal to the task, and all efforts to keep it up were abandoned. Much of it is now destroyed.

Mount Vernon is the largest town on the Skagit, but trade is so scattered—a store and steamboat landing being established every 3 or 4 miles from the mouth of the river up 40 miles or more—that no considerable town yet exists on the river.

Back of the marsh and bottom lands on the south bank of the Skagit are many hundred million feet of timber, which, when cut, must be brought out to the river if a channel is not made back of the marsh, at the foot of the highland, to float the logs to salt water. Loggers, millmen, and farmers are all interested in it, and they are now seriously considering the proposition of cutting a ditch commencing 2 miles south of Mount Vernon and extending along the foot of the highlands to the Snohomish County line, and on that line to Skagit Bay. It is proposed to make this ditch 25 feet wide and 6 feet deep, and to use the earth thrown out in making a road. This ditch would be 9 miles long. It would cut off all seepage from the highland and thoroughly drain the back part of the marsh. It would also bring all logs cut back of it to salt water without river driving. It is estimated that such a ditch and road would cost $25 per rod, or $72,000 in all. At that cost it would pay for itself in a very few years.

Another matter is a subject of serious consideration on the Skagit. The drift accumulated in the Lower Skagit prevents the rapid flow of water in times of freshets, and has helped largely to increase the destructiveness of freshets on that river.

The three freshets which did the most damage on the Lower Skagit were in March, 1881, June, 1882, and November and December, 1883. The first and last affected the Stillaguamish also, but not the one in June, 1882. The two last were the worst.

The conclusion is being reached that the tract south of the river can be protected only by a dike running parallel with the river and extending to Mount Vernon from the Snohomish County line. The Skagit rises as high in summer as in winter, and as a summer overflow on growing crops is ruinous, it will be necessary to make a dike high and strong enough to keep out the highest freshets. It should be 6 to 12 feet high, with a base 30 to 50 feet wide and 12 to 15 feet

wide on top. This would afford a wagon-road. The dike, with dams or flume-gates in the sloughs, would cost $80,000. This would protect about 10,000 acres, and pay for itself within five years. If built and adopted as a public highway, the ordinary road taxes would keep it in complete repair. The distance from Mount Vernon to Stanwood by this route is about 17 miles. Probably the ditch already described will be constructed first, but both will some day be completed. Most farmers look upon the present dikes as affording in most cases only temporary protection until capital can be accumulated to complete permanent and substantial improvements.

The Samish Flats are in the northwestern part of the mainland of Skagit County, and have a frontage of 10 miles on Bellingham and Padilla Bays. In front of the flats is Samish Island, which is cut off from the mainland by a tide-marsh slough, and separates Bellingham Bay from Padilla Bay. The island contains about 1,100 acres, of which 700 acres are highland and the rest tide marsh. Of the 400 acres of tide lands about 300 acres on the southeast side of the island are school lands and 100 acres on the northeast side have been diked since 1878.

The Samish River, which flows into Bellingham Bay near Samish Island, is navigable for steamboats 3 miles and for canoes 10 miles. By cutting out jams it could be made navigable for canoes 20 miles from its mouth. At one point it is only 4 miles from the Samish River to the Skagit, and the intervening land is marsh or low bottom. It is supposed that formerly the Skagit discharged into Bellingham Bay through what is now Samish Slough, and that its old channel cut across the present channel of Samish River. Conceding this, the present Samish Flats are made from sediment deposited by the Skagit.

Back of the Samish Flats, and near the head of the East Fork of the Samish River, are great quantities of fertile bottom land, and on the highland immense quantities of fir timber.

From the north end of the Samish Flats to the Fraser River nearly all the fir timber within 20 miles of salt water has been destroyed by forest fires, excepting what is east of Whatcom Lake and the South Fork of the Nootsack. From the Samish southward to the Puyallup fires have done little damage, and the most valuable timber is still standing.

The town of Edison, established in 1881 on Samish Slough, near the center of Samish Flats, is the business center for these "flats." It is about 15 miles from Edison to Whatcom, and an equal distance to La Conner.

Mr. Legg, one of the foremost farmers of this section, says that much reclaimed tide marsh will yield from 4 to 5 tons of timothy hay at a single cutting. He has pastured his meadows until the last of May, and two months thereafter has cut 3 tons of hay per acre over the whole meadow. The later in the spring cattle are pastured on the meadows

the finer the timothy will be that year. Where everything is favorable for a rank growth it is necessary to have the ground thickly set, or the hay will be too coarse for cattle, and it is likely to be so the first two years even with heavy seeding. Mr. Legg puts on 20 pounds of seed per acre to get fine hay. Alsike and white clover thrive, and cattle fatten on them. Red clover is well adapted to the poorer soils of the uplands, but on the river bottoms or marsh lands, and in particular on tide marshes, it grows too coarse and woody. While still growing it is apt to fall down and mildew, and is very difficult to cure. White clover is excellent for pasturage, but alsike is the best clover for meadows. On rich soil it grows 4 feet tall and cures perfectly. Most farmers sow timothy on marsh and other bottom lands and clover on the highland. With average winter range on tide lands cattle require little hay before the 20th of February. The most feed is needed in March, and some in April, until the fresh feed will give strength. Mr. Legg is of opinion that two 10-acre fields, by changing each week, would support 50 dairy cows for eight months in good condition. Mr. R. B. Dawson has kept six cows and five other cattle on 7 acres, without other feed, and during the season the cows yielded 700 pounds of butter.

No disease has ever appeared among cattle on the Samish, and sheep do as well as cattle. They are not subject to foot-rot on bottom land around Puget Sound, though it frequently occasions loss on the high, dry Nisqually plains. Farmers purchase sheep so diseased and drive them to the White River Valley, where they soon recover.

On the Samish, as on the Stillaguamish, farmers are going into stock and hay raising, and the area of grain is decreasing. For some years beef has been high and logging active. Surplus hay when baled finds a ready market in the logging camps at from $12 to $20 per ton.

On the Samish there is another reason for giving the preference to grass. The tide flats in front of the marshes extend 2 or 3 miles out from shore, and prevent, except near the main river and the sloughs already described, that deep drainage which grain requires. Oats stand more wet than other grain, and are therefore put on the worst-drained land. Wheat is more sensitive than barley or oats. A slight difference in drainage will make all the difference between 10 and 60 bushels per acre of wheat. Barley may yield from 15 to 70 bushels and oats from 25 to 125 bushels per acre, depending on a difference of 18 inches in the drainage. Good crops of hay are secured with 1 foot less drainage than grain requires. If standing water does not come within 18 inches of the surface, and the ground is properly seeded, 3 tons of hay per acre may be expected. Where the surface is not too soft, cattle will find excellent pasturage with water 1 foot below the surface. On three-fourths of the Samish Flats standing water comes within 15 inches of the surface during the growing season. Farmers there are agreed that deeper drainage is desirable. Mr. Legg thinks that good drainage would more than double the present average yield of the flats. It will

all be secured in time, but the country is new and this improvement must take its turn after some others. In the mean time farmers make money by keeping cattle and making hay.

On the Samish Flats 4.210 acres have been diked and 1,950 acres remain unimproved, of which the greater part may be diked within the next two years.

In 1878, 500 acres on the Samish produced 21,400 bushels of oats; 1879 shows a total of 32,000 bushels of grain on 725 acres and 250 tons of hay on 100 acres.

The crops of 1880 were 32,000 bushels of grain on 600 acres and 360 tons of hay on 200 acres. The product reported for 1881 is 26,000 bushels of grain from 550 acres and 350 tons of hay from 200 acres. For 1882 the estimate is 30,000 bushels of grain raised on 520 acres and 600 tons of hay on 300 acres. For 1883, 25,000 bushels of grain raised on 440 acres and 700 tons of hay on 440 acres are the estimates.

Within the boundaries of Skagit County are twenty-two islands, exclusive of tide-marsh islands in river deltas, &c. The total area of these islands is 42,112 acres. Fidalgo Island has an area of 25,586 acres; Guemes Island, 5,595 acres; and Cottonwood Island, 854 acres. The others are quite small, many of them mere barren rocks, and none exceed 500 acres in area.

Cottonwood or Sinclair Island is north of Cypress Island and between it and Lummi Island. It has been settled since 1868, and there are several good farms on it. Excepting about 50 acres of rocky fir land, it is mainly low and level, good agricultural land, and where not cleared is covered with cottonwood, alder, cedar, willow, maple, &c. There is no considerable amount of tide marsh on the island.

Guemes Island is north of Fidalgo and east of Cypress Island. It is separated from the former by the Guemes or Ship Harbor Channel, from the latter by Bellingham Channel and from the mainland by Bellingham Bay. In shape the island resembles a shoe. It is level except near the east end, where it is bold and rocky and covered with fir. About 1858 fire swept over the level portion of the island, since which a second growth of alder, &c., has come up.

On the island are 125 acres of tide marsh, all diked by beach. William Whalley, who settled there in 1872, has 40 acres of tide marsh well drained and in cultivation. It was reclaimed in 1878 by placing flumes and boxes in the beach and ditching the marsh. That year he had 900 bushels of oats and 2 tons of oat hay from 18 acres. In 1883 he had 60 tons of hay from 25 acres.

On the west side of the island is a larger marsh, owned by James Morrow, who is reclaiming it.

Fidalgo Island, in its eastern part, is comparatively level, but the western part is very irregular. Mount Erie rises steep and rugged 1,250 feet. Its summit affords an excellent view of most of the islands of the lower sound, as well as the mainland in Whatcom, Skagit, and Snoho-

mish Counties. Sugar Loaf Mountain, just north of Mount Erie, rises 850 feet, and from its summit a view may be obtained of the west side of the island. On these summits the primitive rocks are bare and display the marks left by the glaciers on their way southwestward to the sea. This part of the island also contains many beautiful, deep, and clear fresh-water lakes, the largest of which cover areas of about 300 acres each. About two-thirds of the whole island is fertile agricultural land, and most of the rest is valuable for timber or pasturage.

H. A. March began bee-keeping on the island in 1880 with 4 swarms of black bees and Italian queens. In 1883 he had 25 hives of Italian bees. From them he sold, in bees and honey, to the amount of $280, and had 10 good swarms left to winter. When the clover season was over he found his bees still gathering honey. He noticed that they brought their supplies across Padilla Bay, and, taking his boat, traced them to the Swinomish tide flats, 7 miles from home. About one-half of this distance was over Padilla Bay. Acting on this hint he took one of his bee-stands to Swinomish Slough, near La Conner. Here the bees worked on the "golden-rod," which grows on the dikes, and furnishes large quantities of excellent honey after clover is gone. While a swarm at home gathered only 18 pounds of honey, this one close to the "golden-rod" gathered 65 pounds. As clover can be raised so easily on tide-marsh lands, and "golden-rod" grows so rank upon the dikes, it is reasonable to suppose that the tide lands will become famous honey-producing regions. Prior to the settlement of the country there was little wild food for bees anywhere around Puget Sound. Now *honey dew* is found in the woods, thousands of acres are being seeded to clover, and many weeds of value to the bee-keeper are taking root. The winter's dampness is the greatest obstacle to be encountered, but from this source none have suffered loss who have cared for their bees.

On the whole island outside of the reservation there are now about 1,000 acres of land in cultivation, 700 acres slashed and in process of clearing, and 90 acres in orchard. One hundred and seventy-five acres of tide marsh have been reclaimed, and less than that area remains unimproved.

The greater part of the tide lands of Fidalgo Island are on the Swinomish Indian Reservation. The Indian population is about 200, the main Indian town being near the south end of Swinomish Slough, opposite La Conner. Here, and for some 3 miles to the northward, the west shore of the slough is high, but farther north there is a large tract of tide marsh in the reservation.

In 1882 Mr. Baldwin, "farmer in charge," induced 20 or more Indians to undertake the task of diking in a part of this marsh for themselves. By the end of 1883, 400 acres were protected by a dike 4½ feet high, 12 feet wide at the base, and 500 rods long. The dike cost $1,300, or would have cost that sum if it had been built by white men. Four large sloughs were dammed, at a cost of $2,100. When the diking was

completed the reclaimed land was surveyed and divided among the Indians in proportion to the work done by each. These Indians have built 500 rods of fence jointly and 340 rods more individually, and erected five dwelling-houses. Three hundred acres of tide land in the same tract remain undiked.

Fidalgo and Guemes Islands have 1,200 acres of tide marsh, of which 600 acres are now fit for cultivation.

The tract of land known as Swinomish Flats is 6 miles long and from 2 to 4 miles wide, with branches extending eastward towards the Skagit River. The course of Swinomish Slough west of the flats is nearly north and south, while the river runs from northeast to southwest.

Some 8 miles from the mouth of the Skagit it divides into two channels, known as the "South Fork" and "North Fork." These two forks inclose a delta containing some 10,500 acres, most of which is tide land.

Three miles below its head the South Fork divides into two channels, which are again divided lower down. Only one small channel can now be navigated by steamers, the others being stopped with drift. The largest is filled from bank to bank for 3 miles. A jam also extends across the head of the North Fork.

Farmers in the Padilla settlement have come to the conclusion that their tide lands need underdraining as well as diking. The mole-plow has been used, but it was not a certain success. The method now generally adopted is as follows: A ditch is dug 2½ feet deep and 10 inches wide at the bottom. Split cedar bolts 16 inches long and 1¼ inches thick are then set in the ditches so that one end rests on the bottom at one side and the other end against the opposite side of the ditch some 10 inches above the bottom. The ditch is then filled, leaving a triangular space underneath the timber, the top edge of which is 20 inches below the surface. It costs less than 40 cents a rod to dig such ditches, buy the bolts, put them in the ground, and fill the ditches. R. E. Whitney put in 4,000 rods of such covered drains in 1882 and 1883, and during 1884 will put in 1,000 rods more, and continue until all of his land is thoroughly drained.

Peat lands suffer more than clay from drought, but when well underdrained they are not seriously affected. In Mr. Whitney's opinion, as a consequence of underdraining there is a saving of 25 per cent. in team work, and crops can be got in earlier and in much better condition and with greater assurance of a bountiful yield. Another advantage is that well-drained ground may be plowed in the winter, when undrained land will not bear a team. Hundreds of acres were plowed and ready to sow last March which before they were drained could not be worked before the 1st of June, and sometimes the whole season was lost.

In what is known as the Jennings neighborhood, on the Swinomish Flats, 1,325 acres have been protected by 7 miles of exterior dike, which cost, including dams and sluices, $13,400, or $6 per rod of dike and $10

per acre of ground protected. The dikes in question vary in width of base from 6 to 12 feet and in height from 3 to 6 feet.

The following estimate is given of crops in the same district for the years from 1879 to 1883. The "grain" was principally oats, although considerable areas of barley and wheat were cultivated.

Year.	Grain.		Hay.	
	Acres.	Bushels.	Acres.	Tons.
1879	700	60,000	30	60
1880	850	64,000	50	100
1881	850	65,000	75	160
1882	825	63,500	100	300
1883	860	62,000	110	275

Samuel Calhoun settled on the Swinomish Flats in April, 1864. He began diking in 1865, and harvested his first field crop, 21 acres of barley, in 1869.

By 1875 the Calhoun Brothers (Doctor and Samuel) had in cultivation nearly or quite 400 acres of land. That year their crop of grain was nearly 30,000 bushels on about 320 acres. In 1876, 400 acres produced 33,000 bushels of barley and oats.

In 1877, 410 acres on the Calhoun farms produced 35,407 bushels of grain and 40 acres yielded 130 tons of hay. One-fourth of the grain was barley, raised on about 110 acres, and the rest oats, on 300 acres. It all averaged over 86¼ bushels per acre. Similar crops were raised in 1878.

In 1879 Calhoun had 24,400 bushels of oats on 320 acres, 930 bushels of wheat on 30 acres, and 120 tons of hay on 40 acres.

The crops in Calhoun's district since 1878 may be estimated as follows:

Year.	Grain.		Hay.	
	Acres.	Bushels.	Acres.	Tons.
1879	390	28,300	60	160
1880	405	29,500	60	160
1881	445	31,500	60	145
1882	450	26,860	60	130
1883	595	34,210	165	150

The following amounts of hay and grain were raised from 1879 to 1883 in the La Conner district:

Year.	Grain.		Hay.	
	Acres.	Bushels.	Acres.	Tons.
1879	790	55,500	30	90
1880	836	62,083	36	100
1881	871	60,148	36	100
1882	755	53,800	49	107
1883	764	62,940	48	132

La Conner has grown steadily with the improvement of the tide lands which surround it, and its trade is a fair index to the condition of the whole Swinomish Flats, of which it is the business center.

The first grain shipped to California was 400 tons of the crop of 1874. Of the crop of 1875 about 1,000 tons were shipped to California. All grain is shipped in sacks. A bushel of oats is 36 pounds, of barley 46 pounds, and of wheat 60 pounds. A sack of barley is supposed to contain 2¼ bushels, of wheat 2 bushels, and of oats 2½ bushels. Usually they overrun in weight. It is not strange to find oats weighing from 38 to 40 pounds to the bushel, and crops are sometimes reported as weighing 42 or 43 pounds to the bushel. An average crop of oats, as thrashed in the field, will weigh from 37 to 38 pounds to the bushel. The large steam-thrashers are taken into the fields and the grain hauled to them from the shock, without having been stacked or put in barns.

The statements given of the yield of grain are obtained from the thrashers. The price for thrashing has varied from 2 to 8 cents per bushel. The average for the past six years for all kinds of grain has been less than 4 cents, and not much over 3 cents for oats, the chief grain raised.

In 1880 the price of thrashing was much lower than ever before. Then oats and barley were thrashed at 2½ cents per bushel and wheat at 4 cents.

The grain trade of La Conner has averaged for the last three years about 12,000 tons per annum. It is of sufficient importance to bring dealers from Seattle and San Francisco. Only oats are shipped. The wheat and barley are used at home, the latter being ground and fed to oxen in logging camps.

The net cost of raising oats and preparing them for shipment is estimated at $10 per ton, barley $10 per ton, and wheat $20 per ton. This includes the cost of placing them on the steamers, and may or may not include the cost of sacks, which is from $2 to $2.50 per ton. The cost of putting oats on the San Francisco market from the farmers' warehouses is, for local and ocean freights, warehousing, insurance, commissions, &c., from $6 to $7 per ton.

Farmers receive an average of $20 per ton and upwards for all oats shipped. The highest price paid during any one year was in 1877, when oats sold in San Francisco for $35 to $50 per ton. All who sold before Christmas of that year realized at home from $30 to $35 per ton. The lowest average price was in 1879, when farmers received about $16 per ton. In 1880 the home price was $17.50 to $18, many holding over; in 1881, $22; 1882, $26; 1883, $25.

Settlement of the Swinomish Flats began in 1864, diking in 1865, and field cultivation of grain in 1868. No considerable improvements were made and but little grain was raised prior to 1870. By 1874 about 1,100 acres were in cultivation. This was increased to 3,000 acres in 1876 and to 5,000 acres in 1878, in hay, grain, orchard, tame pas-

tures, &c. The total area of all the Swinomish tide-marsh land is 11,000 acres, and 8,000 acres are now under dike. Sixty-two miles of dike have been built, nearly 15 miles of which have become interior dike. This dike has cost $72,000. In 1884 there will be cultivated about 5,200 acres in grain, 800 acres in hay, 200 acres in orchards and vegetables, and 800 acres in tame pasture, or 7,000 in all.

Below Sterling and west of the Skagit River are 50,000 acres of bottom and marsh land, all but 10,000 acres subject to Skagit River overflow. The Swinomish Flats cover 11,000 acres, the Beaver Marsh nearly 4,000 acres, the Olympia Marsh 15,000 acres, the Jennings and other fresh-water marshes 5,000 acres, and about 5,000 acres more are bottoms covered with timber and subject to overflow. The Jennings district of fresh-water marsh land consists not of one continuous tract, like the Olympia Marsh or the Beaver Marsh, but embraces all the small tracts of marsh land scattered through the timber between the Olympia and Beaver Marshes. Of all this fresh-water marsh land 2,000 acres are nearly free from timber. The Beaver Marsh is the only part where any systematic efforts have been made to reduce large bodies to cultivation. There the only obstacle to successful cultivation is the overflow from the Skagit. Already $18,000 have been spent to secure protection from this evil, with only partial success.

During the years from 1879 to 1883 crops of hay and grain have been raised on the Swinomish Flats as follows:

Year.	Grain.		Hay.	
	Acres.	Bushels.	Acres.	Tons.
1879	4,173	282,950	375	980
1880	3,815	259,658	421	1,095
1881	4,031	280,913	491	1,190
1882	4,048	243,585	638	1,447
1883	4,330	307,400	703	1,797

All the hay raised on Swinomish Flats in 1879, 1880, and 1883 averaged over $2\frac{1}{2}$ tons per acre, while that raised in 1881 and 1882 averaged over $2\frac{1}{4}$ tons per acre. The average of grain was, for all raised on the flats:

	Bushels per acre.
1879	$67\frac{3}{4}$
1880	$68\frac{1}{10}$
1881	$69\frac{7}{10}$
1882	$60\frac{1}{6}$
1883	71

The freshet of 1882 on the Skagit River flooded enough of the Swinomish Flats to reduce the average grain crop some 9 bushels per acre, or to reduce the whole grain crop of the Swinomish Flats over 40,000 bushels. It also reduced the hay crop, and damaged grain that was saved, and damaged dikes, &c., so that the total damage on the Swinomish alone in 1882 by this freshet was some $30,000.

From 1878 to 1882 there was little increase in the number of acres

seeded to grain each year, but a marked increase in the number of acres in meadow. Except in 1882, the yield per acre of grain shows a regular increase for each year. In 1883 there is also an increase in acreage and yield of grain, as well as of hay, and a large increase of the acreage of hay and grain is noticeable for 1884. The only years when any considerable crops were raised on the Beaver Marsh were 1879 and 1883.

The Skagit River Delta, between the South and North Forks of the Skagit, is all bottom land, and the greater part tide marsh. It is divided by numerous sloughs and channels, only a portion of which are laid down on the plots of the United States Government land surveys.

The delta comprises 10,500 acres of land, of which 1,500 acres may be classed as ordinary river bottom, 4,500 as brush and spruce tide marsh, and 4,500 acres as open tide-marsh prairie. About 300 acres of river-bottom land and some 500 acres of spruce and brush tide marsh have been cleared. So that at present there are 5,000 acres of open tide marsh within the delta.

The crops raised on tide-marsh lands within the Skagit Delta were:

Year.	Grain.		Hay.	
	Acres.	Bushels.	Acres.	Tons.
1879	1,203	66,500	70	175
1880	1,256	55,000	124	385
1881	1,152	91,270	149	430
1882	1,122	40,450	210	510
1883	1,245	100,400	215	590

Nearly 37 miles of dikes have been built in the delta, at a cost of $30,700. Of these 7 miles are now interior dikes and 5 miles have been so damaged by floods as to be of little service, leaving 25 miles of efficient exterior dikes. The freshets of June, 1880 and 1882, damaged dikes and dams within the delta to the amount of $8,000, and the grain crop of 1880 was reduced one-third and that of 1882 more than one-half, a total loss in dikes, buildings, and crops of $50,000. In 1880 many fields of grain were so far advanced that the water killed but little. The freshet of 1882 came earlier and was much more destructive.

In reference to leasing tide lands two letters are here submitted.

Dr. H. P. Downs, auditor of Skagit County, writes:

The usual terms of lease of tide-marsh lands are: Improved lands, lessor has one-third of the crop, delivered at nearest shipping point, lessor to furnish sacks for his one-third and lessee to furnish team, feed, and seed in raising crop. If lessor furnishes teams, feed, and seed, he has one-half of the crop and furnishes sacks for his share. If lessee breaks the land, he has the whole of first year's crop. If the crop is hay, lessor has one-half, to be delivered at nearest shipping point, and furnishes bale-rope for his share.

D. O. Pearson, as notary public, draws contracts and leases for the people on the Stillaguamish. He writes:

The usual terms of renting here on improved farms are, if the owner of the land furnishes team, tools, feed, and seed, one-half; if the owner of the land furnishes nothing but the land, he, the owner, gets one-third. Where land is diked, but the sloughs not

filled, the parties renting fill the sloughs and get the logs off, and brush if there is any, and have the use of the land for two years. On my Swinomish farm I get one-fourth, the renter seeding down 60 acres and doing considerable fencing, for which he gets no pay. He has the place for five years.

In Skagit County, east of the tide lands and west of a north and south line passing through Sterling, there are over 40,000 acres of fresh water marsh, of which nearly 25,000 are free from timber. The fresh-water marsh land does not differ from tide marsh in character more than one tract of tide marsh differs from another, except it is above tide level and as a rule contains more peat than the tide marsh. Over 80,000 acres of this marsh and bottom land needs diking to protect it against Skagit River summer overflow.

In all of Skagit County fully $175,000 have been spent in building dikes and dams to reclaim these lands, and nearly 150 miles of dikes have been built, of which over 100 miles are now efficient exterior dikes, that represent a cost of $125,000, and protect 20,000 acres of land. Thirty miles of interior dikes are standing, but of no present use, and 20 miles of dikes have been destroyed.

SUMMARY.

Upon the east side of Puget Sound, including Island and San Juan Counties, are 67,000 acres of strictly tide-marsh land, of which 50,000 acres are open marsh or tide-marsh prairie. Of this 26,000 acres are now diked and 16,000 acres under cultivation. Two hundred miles of dikes have been built, at a cost of $245,000. Of these 140 miles are exterior dikes, 25 miles have been leveled or destroyed by floods, and 35 miles are interior dikes of little present use. The exterior dikes have cost $185,000, the dikes destroyed $25,000, and interior dikes $35,000.

TIDE LANDS.

	Acres.
Pierce County	6,400
King County	1,200
Snohomish County	18,000
Skagit County	32,000
Whatcom County	4,000
Island County	4,000
San Juan County	600

DIKES.

	Miles.
Skagit County	150
Snohomish County	37
King County	6
Whatcom, Island, and San Juan Counties	6

COST.

Skagit County	$175,000
Snohomish County	50,000
King County	9,000
Island County	5,000
San Juan and Whatcom Counties	3,000
Pierce County	2,000

Upon the west side of Puget Sound and on the Skokomish, Hood's Canal, the Strait of Fuca, and around the head of Puget Sound are 5,000 acres of tide marsh, with less than 1,000 acres under dike.

Upon the Lower Columbia, in Washington Territory, are 3,100 acres of tide-marsh lands; on Shoalwater Bay, 20,000 acres; on the Chehalis River and Grey's Harbor, 60,000 acres; on the ocean coast north of Grey's Harbor, and including the Neah Bay Indian Reservation, 20,000 acres, or 103,000 acres west of the Olympic and Coast Range Mountains. Sixty-three thousand acres of this is tide-marsh prairie or open marsh, and 40,000 acres spruce or brush marsh.

In all of Washington Territory there are 230,000 acres of land to be diked, 28,000 acres under dike, and 17,000 acres in cultivation. Two hundred and ten miles of dikes have been built, costing $255,000.

OTHER MATTERS.

The saw-mill towns are on the western side of Puget Sound. The towns built by the people, and which represent the general progress of the sound country, are all on the east side, except Port Townsend and Olympia, the Territorial capital.

Seattle is the commercial center of the sound country, and claims from 10,000 to 12,000 people.

The places heretofore known as Tacoma, New Tacoma, &c., are now consolidated under the name of Tacoma. This place is supported by the Northern Pacific Railroad; present population from 5,000 to 6,000.

Port Townsend and Olympia each claims a population of about 3,000.

Whatcom, or some point near thereto, has the greatest *natural advantages* for becoming the "great city of the future," but these advantages are as yet undeveloped.

The local and export trade of the river valleys on the east side of the sound was worth over $10,000,000 in 1883. Over $5,000,000 worth of logs, lumber, hay, grain, hops, shingles, and other products were shipped from these rivers in 1883, and over $4,000,000 worth of this trade was controlled by Seattle, as well as the trade of the great New Castle mine and of the mill towns on the west side of the sound.

The trade of the Carbanado coal mines centers at Tacoma.

Whatcom has a population of from 1,200 to 1,500.

Snohomish City, on the Snohomish River, is the largest town not on salt water in the Puget Sound country. Its population is from 800 to 1,000.

Puyallup Station, on the Puyallup River, is the next most important river town.

Everything indicates that within a few years all available Government land in Western Washington will be occupied, and that the progress of the whole region will be rapid and permanent.

IX.—CORRESPONDENCE.

MAINE.

HANCOCK AND WASHINGTON COUNTIES.

[Samuel L. Boardman.]

The eastern coast of Maine is a rigid granitic coast, and the tide flows back the rivers but a short distance generally, on account of the rapid descent of most rivers to the sea. On the Pleasant, Narraguagus, and Machias Rivers, in the western and central portions of Washington County, there are extensive tracts of salt marsh, and in Perry and Pembroke, in the extreme eastern part, are small marshes from 4 to 20 acres.

The most extensive examples of diked land are on Machias River and Middle River. The marsh on Machias River, near Machias Village, has been diked for many years. The soil is a fine, non-adhesive sand, which dries and blows and does not compact like the alluvial deposits of the New Brunswick rivers. The common rise of tides about Machias Bay and rivers is 12 feet, storm tides rising to a height of 15 feet. On this old dike, below Machias Village, the shifting nature of the soil is such that the sea often tears it away, and outside planking is resorted to in order to keep it intact. The diked land here is held at a valuation of $50 per acre, which does not differ much from that of improved upland.

On Middle River, Machias, is a tract of some 400 acres which was diked in 1869–'70. The soil of this marsh was a thin clay, resting upon a peaty, quaggy subsoil of vegetable débris some 3 feet in depth. The common tides here have a rise of 12 to 15 feet. Great expense attended the reclaiming of this marsh in the construction of an *aboiteau* * across the river 3 miles from the sea. This dike and *aboiteau* were over 90 rods in length. In some places it was necessary to use piling to support the dike, and to obtain upland soil at a distance of 30 rods from the dike to help in its construction. This dike cost about $60 per acre of reclaimed land. For two winters after it was constructed the land was overflowed with fresh water and the water allowed to remain on the land, in order to take out the salt from the soil. The growth is chiefly timothy on the higher portions and blue joint grass (*Calamagrostis Canadensis* on the low places. It was several years before the English grasses became at home on this marsh after it was diked, but now good crops of hay are taken off annually.

Some years ago an attempt was made to reclaim a marsh at Bucks Harbor Neck, in Machias Port, but it did not succeed, as the dike was not substantially built. There is not a great extent of marsh land about our eastern coast that is susceptible of improvement by means of diking, and until upland is more generally employed in agricultural op-

* An *aboiteau* is a dam placed in a tide-water channel, having a sluice-way through it and forming a part of the dike.

erations, and markets for farm crops become better, but little will be done at reclaiming salt marsh, on account of the heavy expense necessary in building the dikes and *aboiteaux*.

WALDO COUNTY.

Waldo County fronts on Penobscot River and Penobscot Bay a distance of 40 miles. The marshes are both salt and fresh, but not of great extent, and little attention has been given to their improvement. A marsh of 50 acres on an arm of the Penobscot was diked about the year 1873, but the tide-gates, not being well secured against the action of ice, were carried out, and the improvement was abandoned.

KNOX COUNTY.

Knox County is on the west side of Penobscot Bay, where it opens to the ocean. The coast is mainly rock-bound, but marshes are found inland along the tide rivers and creeks.

[L. F. Starrett, clerk of the county court.]

The marshes in Knox County are situated mostly in the town of Warren, on the upper tidal waters of the Saint George, and in the towns of South Thomaston and Thomaston, on the upper tidal waters of the Wessaweskeag River. There are, along the whole extent of coast, creeks emptying into the ocean and the various coves and other inlets which are bordered by small strips of marsh, but the principal amount of it lies as I have indicated. The marshes of the Saint George commence a short distance below the head of tide and extend down some 4 or 5 miles. In some places they are very narrow, in others they widen out to 15 rods or more. Generally where the marsh is broad on one side of the river it is narrow on the opposite side. Where there are creeks running into the river the marshes extend back along the creek, in some instances as far as 50 rods, the same general law of formation governing as along the rivers. There is also some marsh on the Oyster River, a small tributary of the Saint George.

It has been of late years the custom of the assessors of the town of Warren to make no statement in their inventory of the different kinds of land owned by a person liable to taxation, but to state the total number of acres, and consider the quality in arriving at an average rating per acre. I think the marshes are regarded as of much less value now, as compared with uplands, than in former years. They were highly esteemed by the first settlers, because they found them ready cleared. Choice pieces of marsh were valued at from $50 to $75 per acre, which are not considered worth more than $10 or $15 now. Few pieces, however, are sold. The farms on either side are bounded by the river, and the owners, even if there were those who might wish to purchase, would have little inclination to sell to a purchaser who must necessarily cross their land to get to and from the marsh. The fact that much marsh grass is now left standing where formerly it was all cut indicates that marsh property is not so highly esteemed as it once was. I think that, as now managed, and considering the difficulty of getting the hay from them, the Saint George marshes are sources of very little profit.

The coarse grass growing at the margin of the river is termed *thatch*.

This makes a superior mulch for orchards, and much of it is cut and hauled green for that purpose. There are thatch beds on all our tidal streams, whether there be any marsh proper or not, and those on the Saint George extend down much below the marshes proper. They are submerged by the lowest tides, and the thatch must be cut and removed at low water. Above the thatch beds grow finer marsh grasses, which are submerged only by a high course of tides. These furnish hay estimated by farmers to be, when well cured, of about half the value of English hay for feeding purposes. When the marsh is wide there is generally a tract of it nearest the shore, sometimes of considerable width, on which little grass grows. This part is softer than that nearer the river, because not so well drained. Its barrenness is accounted for by the fact that it is constantly saturated with salt water.

I am aware of but two attempts in this county to reclaim marsh land by diking, and both of these were on the Saint George River marshes. The first was made more than forty years ago, by three proprietors of adjacent lots, who inclosed 8 or 9 acres. The dike, perhaps 2 feet high, was built of the marsh muck. A creek near the center was provided with the usual trap, which opened at low tide to let out such water as might have accumulated within, and closed when the tide rose, keeping the salt water out. The drainage was entirely inadequate, and the expectation of the proprietors that shutting out the salt water would cause an improvement in the quantity and quality of hay was not realized. The ditch left in digging the muck from which the dike was built soon became a favorite home of muskrats and other rodents, and in consequence of their burrowings the dike served to keep out the tide water but a few years, and the marsh was no better, but rather worse, for the attempted improvement.

The other attempt at reclamation was made later, and I think that there was a similar failure, for like reasons.

The marshes in South Thomaston are rated on the assessment-books at from $6 to $12 per acre. They are much wider than the marshes of Saint George River, and, I should judge, produce on the average more grass to the acre.

The chief obstacle in the way of reclaiming the marshes is the difficulty of inducing the many proprietors interested to see the advantages of the project and unite in carrying it out.

There are inexhaustible quarries of limestone very near the Wessaweskeag marshes, and lime might be cheaply burned for agricultural purposes if experiment demonstrated the profit of so using it. An experiment with a tight dike and good drainage, continuing a few years, to determine the most profitable method of treating the lands reclaimed, would afford the means of forming a safe judgment as to the feasibility of profitably reclaiming these marshes.

LINCOLN COUNTY.

[Abram T. Gamage.]

It is believed here that ice will break up any ordinary dike in one winter. The ice, which is from 3 to 4 feet thick, rises and falls with the tide, and at every rise crowds the shores from an eighth of an inch to 2 inches, according to the temperature. This crowding is caused by the formation of new ice in the seams opened by the ebb and flow of the tide. I have known ice 2 feet thick to push up 6 feet beyond high-water mark, carrying rocks and trees before it. There is a place near my

house where the marsh sods have been formed by the ice into a ridge 3 feet above high-water mark. This was done when the creek was deeper than at present, and allowed the ice to rise and fall with the tide. This ridge has been supposed to be the work of Indians, but proof to the contrary is found in the fact that sods 10 feet long and 1 foot thick entered into its construction. I also find in some deep creeks the same work now going on.

[F. L. Carney.]

The principal marshes are on branches of the Sheepscott River. There are falls about 6 miles below the head of tide water; above these falls are the most valuable marshes, over which freshets as well as full tide flow. Land is cheap here and labor high. Most of the young men have "gone west," and many farms are not half cultivated. There are large stretches of flats which, would it pay, might be diked.

[Orrin McFadden.]

Area of tide marshes in the county 1,800 acres, rather more than less. Their elevation above low water ranges from 3 to 9 or 10 feet, the highest being on a level with ordinary full tides. Storm tides rise 3 or 4 feet higher. The marshes are owned in small lots and are chiefly alluvial. They are worth very little. Five dollars an acre is a high price for them. Sales are seldom made except in connection with uplands adjoining, which are worth from $5 to $100 per acre, according to quality. The vegetation of the marshes consists of various grasses, water oats, weeds, and lilies. Some is used for bedding and mulching, some fed to stock, and much remains uncut. The obstacle to the reclamation of the marshes is the cost.

SAGADAHOC COUNTY.

Two hundred acres were diked in 1836 or 1837, with good results. This land continued to improve until the tide-gate was removed by ice and the action of the tide. After being abandoned about ten years the gate was replaced, and the land is again improving. Mr. J. A. Stinson, who furnishes these facts, owns diked land on which he raised fair crops of potatoes and oats in 1883, and has hopes of still better success. This is understood to have been salt marsh, as Mr. Stinson refers to the product of the unimproved marshes as "salt hay, used to help out a short crop of hay."

[Washington Gilbert.]

The tide marshes of Sagadahoc County are estimated at 2,000 acres, besides many small fringes. These marshes are near the level of ordinary high water, and are covered 2 or 3 feet by storm tides. They are both alluvial and peaty, and range in value in their wild state from $5 to $10 per acre. The upland adjoining is generally of little value agriculturally. The marshes produce black grass, fox grass, thatch, and weeds, used by some farmers for winter forage. I diked 120 acres in 1882, resulting in a large increase in the growth of the salt grasses in 1883, while waiting for the salt to wash out. I find no insuperable obstacles to profitable reclamation. All difficulties may be overcome by good engineering. On salt marshes in which I am interested are

remains of three old dikes. One was dug down by muskrats; another is very ancient, and shows only a low, broad ridge; the third was suffered to run down by neglect. The farmers owning the marsh lots are mostly sea-coast men, who live in great part directly or indirectly from the sea and never make any improvement on land. Their best land lies waste in marshes and swamps.

[David Work, Topsham.]

The tides here are fresh. The average value of the marshes is $5 and uplands $20 per acre. The formation of the marshes is alluvial, and their product is used for forage and bedding. No attempts have been made to reclaim the marshes. The cost of diking and draining is the principal obstacle.

CUMBERLAND COUNTY.

[The commissioners of Cumberland County.]

This county contains about 4,000 acres of unimproved tide marshes, which are assessed at $12 and would sell for $16 per acre. Seven hundred acres have been diked, mainly in Scarborough. The reclaimed marshes are assessed at $25, the dikes having cost $10.50 per acre. Sales made indicate a value of $50.

Diking is in progress in several localities. The obstacles to greater progress are want of information, prejudice, and expense.

[Henry J. Merrill.]

Falmouth contains 700 acres of tide marsh from 2 to 5 feet above low water, submerged 1 to 4 feet by ordinary high water and 6 feet by storm tides. Marsh land ranges in price from $10 to $20 per acre, and upland from $50 to $75. No attempts have been made to reclaim.

[D. R. Stover.]

The area of this town, West Harpswell, is 10,000 acres; 3 per cent. may be tide marsh. The elevation of the marshes above low water is about 8 feet, and the mean rise of tides 9 feet. Neap tides do not cover the marshes. The storm tide of 1861 was 4 feet above mean high water. The marshes are formed of peat or muck and sand. Their value is nominal. No attempts have been made in this town to reclaim. The strictly tide marshes are of small extent, and are regarded as a nuisance, because the milk of cows feeding on them has a peculiar flavor. The storm-tide marshes are for the most part peaty and of great depth.

[H. Hight.]

The reclaimed marsh land in Scarborough comprises nearly 700 acres. It is in some places a mile wide. The soil where the salt water flowed previous to diking is made up of fibrous roots to the depth of 5 or 6 feet. It becomes exceedingly light when dry, but changes rapidly when diked, and must become more and more like the soil of the deep bottom lands or like fresh-water meadows—a *plastic muck.*

The ordinary high tide, while it flowed along the streams and creeks, did not cover the surface of the marshes. Only at time of spring tides

were they covered, and then not often to the depth of 6 inches. The ordinary vertical rise of the tide against the gates of the dike does not exceed 7 feet, and storm tides seldom rise more than 2 feet above the ordinary high-water mark.

The dike is constructed of sods taken from a ditch inside of the inclosure. Along the center of the dike is a sheet-piling of spruce boards driven down into the marsh 2 feet and left 3 feet above the surface. The sod dike is built on each side of and over this piling.

"What is the common method of treating reclaimed marshes at the first and extending through a series of years?" To this question there may be a variety of answers, and concerning the best method different opinions. The common method is the common error of leaving the marshes, as in times past, to take care of themselves. There are those, however, who are experimenting to find out the best method of treating them. Some have secured a good stand of grass by sowing timothy seed upon the marsh, without any cultivation. The marshes near the river have been first to produce good crops of English grass. Some of these have yielded 2 tons per acre and a valuable second crop. Many acres of marsh are now covered with weeds, but these in time will come into good grass if seed is sown, for among the weeds we find bunches of timothy, brown-top, and various kinds of clover, with here and there fine beds of wild strawberries.

Whoever has seen the "bottom lands" of the Western prairie cannot fail to notice their similarity to the salt marshes, or more properly the diked marshes after the characteristics of the salt marsh have disappeared. The Western farmers will tell you that none but a Yankee farmer would think of "breaking" prairie in autumn or early spring. Occasionally one will try the experiment, and as a result you will see on that land dry, unrotted turf for years afterward.

The Western farmer understands that a heavy green crop plowed in will rot the sod during the hot months and sweeten the soil. This is just what is needed to insure a good crop the following season. I am convinced that the marshes need the same treatment. They should be plowed the last of June or first of July, and the more vegetable matter plowed in the better. Deep plowing will hinder the rotting process. In this way the marshes, like the prairies, may be found adapted to almost any crop raised in our climate. One thing, however, works seriously against this plan, and that is the reluctance of New England farmers to plow in a crop of grass. Because of this false economy many continue to cut crops that grow less and less, until there is not vegetation enough left to rot the sod if plowed under.

A Maine farmer in Kansas, having had some prairie broken in June, thought he would have a New England garden. To accomplish this he removed the turf before it began to decay and spaded the prairie, making fine-looking beds, in which he planted vegetables of different kinds. But nothing grew on that spot, while all around it on the rotting turf he had good potatoes, melons, tomatoes, &c.

There are large quantities of tide marsh on the coast of Maine, the reclamation of which would add greatly to the valuation of the State.

[Seth Scamman, S. K. Milliken, E. C. Milliken, S. R. Snow, and I. P. Milliken, West Scarborough.]

Our marshes are vegetable mold, 2 to 10 feet deep. They are 6 to 9 feet above low water, and the highest are near the level of mean high water. Storm tides rise 2 feet higher.

In building a dike much should depend on the pressure it will have to resist. Ours is 10 feet at the base, 5 feet high, and 3½ feet on the top. The turf should not be removed where the dike is built.

For a sluice two lines of piles are driven, 8 feet apart, and sills 7 by 8 inches let into the piles 3 inches at low-water mark. Posts are framed into the sills and extend above the highest water, where a cap-piece connects them. These posts are planked inside and out. Sheet-piling is driven under and at the sides of the sluice, to prevent the passage of water. The bottom of the sluice is formed of 3½-inch plank, laid crosswise. The gates are made of 6-inch timber and 2½-inch planks, put on crosswise. There are two gates in one, the lower one 2 feet high, hanging on the upper with a close joint. The gate stops are 4 by 8 inches. If this sluice is not sufficient to vent the water it may be doubled, but a single sluice should not be made wider than here stated.

Sheet-piling of spruce boards was driven 3½ feet deep in the center of the dike, and muskrats have given no trouble. Our dike cost $10.50 per acre reclaimed. It has been built five years, but little has been done in the way of general cultivation. The greatest value of the reclaimed land is for meadow and pastures. Herds grass and red-top have been generally used. Clover does well.

The land is subject to drought until it becomes compact. It requires no manure.

There are considerable areas of tide marsh in this vicinity that might be reclaimed. All attempts to dike have been successful.

Property rights extend to low-water mark, subject to the right of all persons to dig shell fish.

The effect of reclamation on the health of the neighborhood, if any, has been favorable.

YORK COUNTY.

[Henry A. Stone, South Berwick.]

This town contains about 100 acres of salt marsh, in narrow strips, along Piscataqua River. The soil is black mud, say 6 feet deep, and bears a coarse grass called thatch. No marsh has been reclaimed. It is worth about $6 per acre, and adjoining upland, which is very sandy, $10. This is the most western town in the county. There is very little such land in Elliot or Kittery. York has a large tract on York River. I have heard good judges say that the whole could be reclaimed at an expense of 50 cents per acre by building a dam. Wells also has a large quantity; Kennebunk, Kennebunkport, and Biddeford but little; Saco, now Old Orchard, a large tract.

[Barak Maxwell, Ogunquit.]

Salt marsh is worth about $10 per acre; upland $40. About 150 acres were inclosed last year—the first attempt made in this town. During the last forty years the marshes have decreased in value 50 per cent. When the crop of upland hay is good, as it was in 1883, much of the salt grass is not cut; labor being high and the crop poor, it would not pay to harvest it.

[John Jameson, Old Orchard.]

The surface of our marsh is peaty from a few inches to a foot or more, then mucky to the depth of several feet. In some places it is 15 or 20 feet deep, resting on hard pan. It is perhaps 1 foot above a common

perigean tide, though a storm tide at that season may be from 2 to 5 feet higher. Ordinary tides vary from 4 to 7 feet.

Our dike is constructed of the marsh material, with ditches on both sides. We turf both sides of the dike, but do not remove the turf between the ditches. In our vicinity the cost of diking varies from $2 to $12 per acre.

We flood the land with fresh water both spring and fall, to remove the salt, and as the natural salt grasses die out we sow timothy and red-top.

Our diked land is too soft for general farming or pasturing. We use it entirely for mowing, and it produces two or three times as much per acre as the upland.

There are thousands of acres in Maine that can be reclaimed with great profit. The natural salt hay is not very valuable for feeding.

[Isaiah P. Milliken, Old Orchard.]

Our marsh produces thatch, fox grass, goose grass, and other salt grasses. It is composed of fine, fiber-like roots with very little earthy substance, except near the beaches, where the sand has blown or washed on and made a firmer and better soil. The main body of the marsh is a light and porous substance, which will float in water. The top to the depth of 6 inches is composed of live roots, then fine roots down 3 or 4 feet, followed by coarser roots of thatch and cat-tail flag. I think the body of the marsh rests upon ledge, near the ocean upon sand; that is, sand between the ledge and soil.

Before diking, the full-moon tides flowed over the marsh from 3 to 12 inches. I have not known more than 3½ feet of water on the marsh; that was in 1861.

Our dike is now a town way. It is the usual custom to construct the dike of marsh sod, but on sandy flats or mussel beds it would be necessary to procure other material that would not wash away when a chop drives against it. Where there is surf the ditch should be inside, as any excavation outside will give more force to the waves.

The dike on such marsh as ours should be 6 feet in height, 9 in width at the base, and 2 at the top. The turf for the sides should be cut in squares and carefully laid up, with a good slope on the outside, so as to give a smooth beaching surface to the chop. The middle or filling should be trodden solid. For support to the dike, and to stop musk-rats and mice, boards or slabs should be driven 4 or 5 feet in the marsh and extend the same above, or as high as the water is likely to rise, and the edges should lap 1 inch or more. It would be an excellent plan to plant witch grass and beach grass on the dike. The turf should not be removed before building the dike. The marsh is solid and cannot be made better by disturbing the turf.

The sluice for draining the Little River Marsh is 48 feet long and 7½ feet wide. Piles 20 feet long and 8 to 11 inches diameter were driven 6 to 8 feet below the bottom of the sluice, to form the sides. These piles are 4 feet apart from center to center. They are planked inside with white pine 3 inches thick, and outside, next to the filling, with hemlock of the same thickness, excepting near the top, where the planking on both sides is 2½ inches. The floor timbers are 6 by 6 inches, of oak, and laid lengthwise, and the floor is of plank like the sides. On the piles are cap pieces 10 by 10 inches, and cross-beams 8 by 9 inches, of oak. Spruce sheet-piling 6 inches thick is driven under the sluice and 20 feet on each side. The sluice is 9½ feet deep. The gate timber is 6-

inch oak, the top piece extending out on each side, with rounded ends, which have bearings in blocks bolted to the caps or plates. The gate is 7½ feet wide and 10 feet high with the roller. The bottom part, 1½ feet, swings on hinges independently, so that if the main part should fail to move, the lower part, which is always in water, would let the water out. The gate is near the marsh end of the sluice, so that the tide may preserve the wood (of the sluice) by keeping it wet. Tree-nails are used, as salt water will soon eat off iron spikes, and composition nails loose their hold in the wet wood.

Beginners are apt to make their sluices too short; too long is a good failing. The Southgate Diking Company of Scarborough, of which I am a member, made a great mistake in that way. Streams large enough to require more than 36 square feet to vent the water should be divided by partitions in the sluice.

Muskrats and eels are troublesome. They do not go more than 4 feet deep in our marsh, but they work around a sluice, and must be stopped by sheet-piling the wings, sides, and bottoms.

Such a dike as I have described would cost here about $2.50 per rod.

The cost of diking Little River Marsh was about $3 per acre—the cheapest I know of. The Southgate Marsh has cost $10.50 per acre, and it may take $4 or $5 more per acre to settle the bills.

The Little River Marsh, in which I have about 60 acres, had the tide stopped off December 23, 1872, and I have kept mine in grass or weeds since that time. When drought or winter kills the grass, weeds grow until I get it into grass again. I cut and cure the weeds the same as hay, and my stock eat them. They are very much better than salt hay. The other owners have done the same. None of the marsh has been plowed as yet. Strawberries grow wild and thrive; none have been cultivated.

The soil is so light and porous that it dries very quickly, and dry falls injure the next season's crop. I think we shall have to try holding the water in the ditches or general irrigation.

This land is far superior to upland for mowing, as it produces crops year after year without expense except to cut and secure the crop. It yields 1 to 3 tons, on an average 1½ tons, to the acre. Cattle or horses pastured upon it poach it. I have 10 acres in pasture, but think it worth more to mow. I have been on marsh that was diked forty-two years before, and then in 1871 produced 2 tons of good brown-top hay to the acre. Nothing had been done to it except to sow grass seed and cut the grass. I am told it produces as well now. Timothy and red-top are the best grasses I have seen on such land. I prefer timothy.

The advantages of such lands are found in their deep, rich, and apparently inexhaustible soil, in the small cost of fencing, in their being level and free from stones and the grass from dust and grit, and in the large yield, which materially lessens the cost of the hay.

Salt marshes that can be diked at a cost of $60 per acre—the price of hay remaining as it has been and is—will pay a good profit on the investment. It is feasible to reclaim marshes where storm tides rise 3 or 4 feet higher than the surface, if the wind does not have too broad a rake, that is, a chance to raise a heavy combing chop or breakers. A bank unless supported by stone would not stand the tearing force of breakers. High dikes should always have sheet-piling in the center for a support.

There is a large tract in Scarborough that could be diked at a profit, and I understand the Boston and Maine Railroad Company would dike it cheaply for the owners, but their is a little clam privilege in the way;

also 60 or 80 acres on Sperwink River, in Scarborough and Cape Elizabeth, that could be diked for about $100 per acre, but two or three peculiar persons are in the way who will neither sell nor dike, and they are able to prevent improvement; the others cannot help themselves. Such opposition is the great hindrance to reclamation.

The natural growth of salt marshes is not valuable for feeding excepting a few grasses that grow on marshes which are partly fresh, namely, black grass, marsh brown-top, and five-finger grass. Fox grass, goose grass, branch grass, joint grass, samphire, and many others are worthless for anything but bedding. Sheep will starve through winter on such hay. With a plenty of grain they will do well, as they would on hemlock brush in the same manner. Cattle, horses, sheep, and swine eat a little of it as a condiment, and hens like to scratch in it.

I have not noticed any difference in the health of the neighborhood in consequence of diking, but the green-head horse-fly, which was a terrible pest before, gives little trouble now. We seem to have destroyed their hatching ground or greatly reduced it.

Our sluice for Little River cost, in material and labor, $600; to pass the travel while constructing, and expenses for serving notices on the public in newspapers, $150; and red tape, $300, making in all $1,050. The red-tape item is too big for a little dike.

I would not offer $5 per acre for salt marsh so situated that it could not be diked, and have known parties to urge very hard for low offers. The larger part of salt grass in this vicinity is not cut, and yet many who could dike their marshes are prevented by others who own lots in the same range and will neither dike, sell, nor exchange. They are willing to have their marshes improved but want others to pay the bills.

The legislature enacted a diking law in 1881, but it is full of holes and costs about $400 to use it. I hope the question will be agitated until we get a good law.

NEW HAMPSHIRE.

STRAFFORD COUNTY.

Tide water touches only two counties in New Hampshire, Strafford and Rockingham. The tide marshes of the former, all of which are inland, are estimated at 1,000 to 1,200 acres. They belong to many owners and are valued at $10 to $25 per acre. Adjoining upland farms are worth $50 to $75. None of the marshes in Strafford County are diked.

ROCKINGHAM COUNTY.

The sea-coast of New Hampshire is wholly in Rockingham County. The tide marshes are variously estimated from 4,000 to 25,000 acres the larger amount, no doubt, including many low marshes or flats not included in the other. Most of these marshes are protected from the swell of the ocean and are sufficiently elevated above low water to afford good drainage. As in Maine, a great, and in many cases insurmountable, obstacle to their improvement is found in the lack of harmony among the many owners of small lots.

[Emmons B. Philbrick, Rye Beach.]

Some marshes are worth $5, more from $10 to $20, and a few $50 per acre. Improved upland, suitable for grass, is worth from $30 to $125 per acre.

Diking has not been attempted to any great extent. There are no obstacles which could not be overcome by money and harmony of action, but many owners of a few acres believe that a little piece of good salt marsh pays as well as any part of the farm, there being no outlay for fencing, manuring, or seeding.

Salt hay is good feed, in part, for growing cattle, but of little account for fattening.

In many of the salt marshes near this coast there are stumps and old trees, showing that they were covered by forests.

[Charles A. Nason, Hampton Falls.]

The marshes are owned by farmers living on the border and back 5 miles, in tracts of 1 to 40 acres. Two tracts of marsh land within this county, of 20 acres or more each, have been diked. One soon became a failure. I can learn but little of the work thereon. The other piece, of some 20 acres, situated in the town of Hampton, was diked by Simeon Shaw some fifty years ago, was plowed and cultivated, and very heavy crops were taken off. The timothy crop was as much as could be cured on the ground. Both the above named are now the same as any other salt marsh. The muskrats let in the tide, which washed away the dike. It is believed that many hundreds of acres of these marsh lands could be reclaimed at small cost, being protected by the Eastern Railroad, which is a good dike.

Thirty to forty years ago marsh lands in this town and adjoining were sold for $ 6 per acre. Natural salt grass produced 2 tons of hay per acre, which was worth more than half the price of the best upland hay. Now $45 is the highest price of salt marsh, because all labor to secure the crops is and must be done by hand, at from $1.50 to $2 per day.

If they were reclaimed, no interval lands on the Merrimack or Connecticut would equal them in value, but there are too many owners to agree.

[C. M. Lamprey, Hampton.]

The "Spring Marsh," containing 600 acres and lying in front of Boar's Head (the summer resort), could be perfectly reclaimed by a dike 4 feet high and a half mile long, which would not cost more than $5 per acre of the reclaimed land. When reclaimed this would be the handsomest field of tillable land in New Hampshire, and the most productive.

The "Spring Marsh" and adjoining "Meadows" were flooded nearly two hundred years by the dam of a tide mill, which was taken away in 1879. The mill privilege was granted by the town in 1681 to Brown and others, "to grind ye town's corn," but not to "keep ye water on ye land during ye haying time." From 1681 to 1879 the land was flooded 8 months in a year, and the other 4 months, with no drainage, there was not much hay. The legislature passed an act authorizing the town to purchase the mill and privilege, with authority to tax all flowed lands to pay the cost and interest—this tax to continue not exceeding 5 years

and the land to be exempted from all other taxation during that time. The tax amounted to about two dollars and fifty cents per acre, and was repaid to me in one crop of black grass and salt hay, which was three times larger than at any time during the last 30 years and of better quality.

MASSACHUSETTS.

ESSEX COUNTY.

Statistics and notes from several of the coast towns of Essex County have been kindly furnished by the chairmen of the boards of assessors, through Hon. John W. Raymond, chairman of county assessors, as, follows:

Salisbury.—Marshes unimproved, 2,000 acres; assessed valuation, $18 per acre; average cash value, $18 per acre. Diked marsh, 200 acres; assessed valuation, about $30 per acre; average cash value, $30 per acre. The reclaimed marshes in this town having only been diked two years, are not yet very productive; reclaiming not in progress, except in one instance.

Newberry.—Marshes unimproved, 3,000 acres; assessed valuation, $20 per acre; average cash value, $20 per acre. Diked marsh, 50 acres; assessed valuation, $30 per acre; average cash value, $50 per acre. Reclaiming not in progress. The main obstacles are the close proximity of the ocean and the obstinacy of the majority of the owners.

Saugus.—Marshes unimproved, 700 acres; assessed valuation, $35 per acre; average cash value, $35 per acre; none diked.

Gloucester.—Marshes unimproved, 1,000 acres; assessed valuation, $5,000; average cash value, $5,000; none diked.

Rowley.—Marshes unimproved, 1,200 acres; assessed valuation, $12 to $20 per acre; cash value, $12 to $20 per acre; none diked.

[Asa Pingree.]

Two lots are imperfectly diked, the object being to keep the tide out during haying season. Some ten or twelve years ago an attempt was made to put in a dam and a tide-gate near Oldtown Bridge, where it was intended to reclaim 2,000 acres by an outlay of about $5 per acre. This scheme involved a loss of from two to four years' crops, which the farmers could ill afford. The natural growth of these meadows is valued by most farmers, in comparison with English hay, as 2 to 4. A great many cattle in this locality get no other hay. The average yield per acre is about 1 ton.

NORFOLK COUNTY,

[W. L. Faxon, M. D.]

Some ten years ago I began to dike land at the National Sailors' Home, the diked land producing great crops of grass and vegetables. The dikes have finally come to include 60 or more acres, but as the most exposed portion has been broken about every other year by storms, the result is not so satisfactory as I hope to see it soon. The marsh under plowing soon becomes hard enough to work without difficulty, and any crop can be raised for several years without manure. I have had herd's-grass 4 feet long and rye 6 feet, cabbage 10 pounds to the head,

and other crops in proportion. The fertility of the marshes is beyond question. This is not a farming community, and much of the meadow is owned by the descendants of the old families in Braintree, Holbrook, Randolph, Canton, and Milton, and salt haying is a feature of their life. They would neither sell the marsh at any price nor reclaim it. I am esteemed an idiot for what I have done, and, considering all things, shall not attempt to contradict the opinion. When we can have the marshes in the hands of the Irish and German farmers who are coming they all will be reclaimed. My experience is that the increase of the grass crop on the marsh will pay the expense of diking in two years.

PLYMOUTH COUNTY.

[George M. Baker.]

In Cape Cod Bay a low neap tide is 7.7 feet, spring range 10.58 feet. Major Graham's report on Cape Cod Harbor shows that a twenty-four hours' gale blowing directly into Massachusetts Bay causes a general rise of 3.33 feet.

Much controversy has resulted from the diking of Green Harbor—legal and otherwise—and much has been written *pro* and *con*, and results in other places have been laid before the people. Many believe, others would not be convinced though all of Green Harbor were a garden.

In response to a request addressed to Mr. Baker, the two following statements in regard to the Green Harbor reclamation have been furnished:

[Dr. Henry.]

The soil of the larger portion of the marsh is blue clay. Near the large creeks this is somewhat mixed with sand, which increases to the lower extremity of the marsh. There is also a narrow strip bordering on the sand hills, which separate it from the sea for a short distance, where sand predominates. The clay varies in depth, but the larger part is from 3 to 6 or more feet. Under it is a pan of coarse gravel and stones or sand. The coves and upper extremity are peat. A large portion of the top of the marsh, to a depth of 5 to 8 inches, is a mass of roots of the original salt grasses, which the first few years after the dike was built held sufficient soil among them to produce heavy crops of the English grasses.

This description gives the general characteristics of the marshes on our coast. The surface of the marsh is about 6 feet above the water in the creek through the summer months and four or five in the winter, and is on the same level as mean high water in the bay.

The ordinary vertical rise and fall of the tide is 9½ feet, and storm tides rise 4 to 5 feet higher.

Our dike is built of clay and gravel from the upland and soil from the marsh. It was originally built with a slope of 1 on 1½ for the outside and 1 on 1 for the inside, but I should think a flatter slope for places much exposed to the waves would be safer. I see no advantage in removing the turf where the dike is to be built, only to have the sods to cover the dike when completed. They make a very good covering except where the dike is occasionally exposed to the action of the waves. Such places should be riprapped.

The smaller the sluice can be made, and answer the purpose for which it is intended, the better. A sluice wide on the bottom and with little height will drain deeper than one narrow on the bottom and of suffi-

cient height to give the same capacity. This is sometimes of great importance.

For the first four or five years we obtained the best results by sowing grass seed on the surface, without plowing or harrowing. After that the frost lifted the mass of roots of the original salt grass, not yet decayed, and separated them from the soil beneath, making a spongy mass, in which the foot would sink to the ankle. Since this change we have worked the soil with the plow and harrow.

Where the marsh has been thoroughly cultivated we get better crops without fertilizers than on the upland with good manuring.

The successive droughts of the last three years have killed nearly all the grass on such portions of the meadow as have not been thoroughly cultivated. The cultivated parts are much less affected than the uplands. Red-top and timothy do best, though orchard and foul meadow have done well.

The advantages of these lands are great fertility, freedom from drought, level surface, and no stones. The disadvantages are the tough sod, that requires much working to reduce to proper condition, and the salt that long-continued drought still draws to the surface in some places.

There are more than 4,000 acres in Marshfield and adjoining towns that might be reclaimed with profit. Perhaps want of confidence to some extent, but mainly lack of enterprise, prevents improvement.

[William Hill.]

The land reclaimed at Marshfield, Mass., has an area of 1,412 acres, and is divided by Green Harbor River into two nearly equal parts. The surface of the marsh was about on the level of high water; spring tides flooded it from 1 to 3 feet. The soil was black and spongy, being too soft in most places to bear the weight of a team. Salt hay was its only product, and the marsh was not all mowed, owing to the poor quality of the hay and difficulty of harvesting it. Green Harbor River extends about 3 miles into the country, and receives numerous small tributaries, making it in spring a stream of some magnitude, but in a dry time the flow of water is very small. The lower end of the river below the site of the present dike is know as Green Harbor.

The entrance to this harbor was obstructed by a sand bar, having at low tide about 2 feet of water upon it. The mean rise of tide is about 9 feet, giving at high water a depth sufficient for large craft to cross the bar, and once inside there was sufficient water at all stages of tide for schooners of small capacity. The harbor was used by fishermen, yachting parties, and to some extent as a harbor of refuge.

The principal owners of the marsh conceived the idea that by excluding the sea-water and properly draining the marsh it would become of great agricultural value. They accordingly obtained from the legislature an act granting them the right to construct a dike across Green Harbor River "at or near and not above Turkey Point."

The act also provided that should shoaling take place in the harbor above mean low water it should be removed by the owners of the marsh; or in case of their failure to do so in six months after notice from the harbor commissioners, it might be removed by them, at the expense of the marsh owners.

There was much opposition to the proposed dike by people interested in the harbor. They feared that cutting off of the area overflowed would allow the harbor to fill with sand, on account of the diminished scour outward at low tide. Some of the owners also opposed the proj-

ect, not being willing to incur the expense. The majority, however, being disposed to try the experiment, it was decided to build the dike and assess the land for the money necessary for its construction. Some of the owners refused to pay the assessment, and their land was seized. The dike was to be 6½ feet high above the marsh, and extend from Turkey Point, on the south side of the river, 1,800 feet, in a course north 6 degrees east, to the north side. In its course the dike crossed three channels, one between the small island and the south shore, the main channel, and a small water-way between the large island and the north shore.

First of all two sluices were placed between the small island and the south shore. Three rows of 4-inch sheet-piling were driven across the channel, one row under each end of the sluices and one row midway between.

Except where the sluices pass through them, these sheet-piles extend to high-water mark. The sluices are side by side, each 4 by 4 feet cross-section inside. The bottoms are at low-water mark, or about 17 feet below the top of the dike. The sluices were framed of 8-inch timber, and planked longitudinally on the sides and transversely on the top and bottom. Each sluice is provided with a gate, which swings on gun-metal hinges.

A ditch was dug on the center line of the dike down to hard clay, so that the dike should settle evenly. The dike was then constructed by building out from the upland on each side. The material used was the gravel found in the vicinity. The top of the dike was 6 inches higher than the highest point reached by the tide during "Minot's gale" of April, 1851. A slope of 1½ horizontal to 1 vertical was given to the inside, while the outside was of three different slopes, viz, 1½ to 1, 2 to 1, and 3 to 1. The small channel on the north was filled, in the other small channel was the sluice-way, and the third and largest was the site of the tide-way or apron. This apron was designed to give a passage for the tide until the dike should be in a condition to exclude the water. Between the apron and the shore of the channel two parallel rows of piling and sheet-piling were driven and connected by iron tie-bars. The sheet-piling reached to high-water mark. Earth was then filled in between these two rows of piles. The apron was 70 feet long, measured across the channel. For its construction two rows of sheet-piles, 18 feet apart, were driven about 10 feet into the mud, where they struck hard-pan. These sheet-piles were cut off at low-water mark and the space between the two rows was decked over at low-water level. On the deck, along its middle line, a row of vertical timbers, 5 feet apart, was set up. These posts were double and bolted together so as to leave a space of 2 inches between them, and were braced from their tops to the edges of the apron. The 5-foot spaces were to receive flash boards, which, when the dike was completed on both sides, were to be placed in position at low-water, and the ocean permanently shut out.

As the filling proceeded a large part of the water was forced through the tide-way, and the water in the harbor fell much faster than that above. This caused the water from the marsh to flow over the apron with tremendous force, and cut away the mud and riprap from the lower side of the apron, and the sheet-piles began to float off. At this point all available teams were summoned to fill the tide-way with whatever material could be most quickly obtained. Bags of sand had been provided in anticipation of such an accident, and they, with stone walls, gravel, and other materials, were thrown in, and the structure was saved.

Had the tide-way been wider, or heavier riprap been used, this disaster would have been avoided. It augmented the cost of the dike more than $5,000, as damages had to be paid for the walls, &c., removed. When completed the dam was 4 feet wide on the top and about 6½ feet high above the surface of the marsh.

In 1879 it was widened, at a cost of $3,000, to carry the road between Brant Rock and Green Harbor Village. Its width is now about 30 feet.

The items of expense were as follows:

Earth, gravel, and similar materials	$2,435 20
Lumber and piles	2,842 46
Labor	3,941 79
Bolts, rods, spikes, &c	570 41
Pile-drivers	3,647 70
Gravel filling	12,049 01
Sluices and tide-gates	1,520 64
Sundry expenses	960 84
Interest account	1,131 71
Legal expenses	582 00
Salary of commissioners and collector's fees	2,579 92
Total cost	32,261 68

From the first, thorough ditching has been neglected, owing to lack of funds and the indifference of some owners. Some of the old ditches remained, and a few new ones were dug without regard to any thorough system of drainage. In 1879 from 500 to 600 rods of new ditches were dug by one of the largest owners. Ditches 2½ feet deep cost 25 cents per rod.

The marsh was similar to those commonly found along the coast. The soil was of a dark, rich color, exceedingly spongy and soft. A pole could be run down from 8 to 15 feet. The vegetation consisted of salt grasses, as samphire, sea spear grass, &c. Near the water-courses were found sedges and rushes, while the higher and dryer portions produced small patches of June grass, blue grass, wild foxtail, and black grass. The soil was filled to a depth of several feet with the roots of these grasses, which seem to have accumulated for centuries without decay. The salt grass cut on the margins of the marsh was valued at about $2 per acre, while that in the interior did not pay for cutting.

The first grass seed was sown, without plowing, in April, 1873, 20 acres being of red-top and 15 of timothy. It grew well in some spots, while in others it failed, owing to the salt in the soil. The same year a new grass of rank growth made its appearance and furnished hay at the rate of 2 tons to the acre, but it was of poor quality. In 1874, the marsh having become dryer, experiments were made with oats, potatoes, pumpkins, onions, squashes, and wheat. Generally they looked well, but in some places were killed or stunted, apparently by salt. During the winter of 1874–'75 much of the grass previously sown was killed by exposure of the roots, owing to the lightness of the soil. In 1875 the crops were mostly destroyed by grasshoppers.

Successful attempts were made at plowing, and some oats were sown on the plowed land with good results. The fibrous condition of the soil, owing to the presence of the old roots, has been a great hindrance to its proper working. Continued plowing and harrowing have in a measure broken up the mass, but the process of decay is exceedingly slow. During these early stages of reclamation hay continued to be the principal product of the land. Red-top seemed to produce the most satisfactory results, though timothy did well. In 1876 a measured acre of red-top yielded 3 tons of hay. Rye and oats gave fine results. It is

stated by responsible parties that an acre of rye produced 34 bushels of grain and 5,454 pounds of straw.

From year to year the area of marsh land under cultivation has been increased, and the attending results have been more encouraging, owing to the freshening of the soil. The cultivation of other crops than hay has also increased as the soil has become relieved from saline matter and roots. Onions have been raised with success and are now an important crop, though in certain spots they are killed. This trouble will probably, with proper drainage, be entirely overcome.

In 1880 about 10 acres were burned to a depth of 6 inches, leaving a light loam. In February, 1881, grass seed was sown on this land, which produced grass 18 inches to 2 feet high in June.

The former value of the marsh land averaged about $6 per acre; at present it is valued by the owners at about $40, and the value increases every year as the condition of the soil improves.

Were it not for legal difficulties growing out of the shoaling of the harbor the financial aspect of the enterprise would be good. Previous to the construction of the dike Green Harbor was about 500 feet wide, and extended from the present position of the dike 3,300 feet in a southerly direction to the ocean. The north side of the entrance is a rocky point, while on the south side a beach stretches away 9 miles to Gurnet Head. At the entrance to the harbor was a bar, which still remains. There was a constant warfare between the waves and flood tide, on the one hand, and the ebb tide, on the other, as to whether the harbor should remain open or be closed by the drifting sand from the adjoining beach. There was, however, no permanent change in the harbor from year to year. It was observed that when a northeast storm occurred at a time when the tide did not overflow the marsh, *i. e.*, at the low course of tides, the sand was driven into the harbor, and remained there till the succeeding high course of tides washed it out.

The marsh being at the level of mean high water was not covered till towards the last of the flood tide, and high water on the marsh did not occur till after high water in the sea. When the ebb tide commenced the marsh served as a great reservoir, holding back the water until the level in the harbor had fallen, and then causing a rapid outflow at a low stage of the tide.

In the case of the flood tide, when the channel through which it must pass was small, the velocity was also small, because there was but little filling to be done, and when the tide began to overflow the marsh the channel was much broader, and consequently the velocity was not greatly increased. On the contrary, during the ebb tide the greatest flow took place when the tide had fallen sufficiently to allow the water from the marsh to flow out, its velocity becoming greater as the tide outside fell. The greatest velocity was attained near the close of the ebb tide and the greatest movement of sand then took place. The dike shut off the water from the marsh at all stages of the tides, and the same result followed as though the low course of tides had been permanent, viz, a gradual filling of the harbor. The filling commenced near the mouth and has extended farther up each succeeding year, though not as rapidly latterly as during the first few years after the dike was built.

It seems probable that when the harbor shall have been filled to a certain point the equilibrium between the two forces will be again established, and no further change will take place. Perhaps that point has been already reached.

The bar was formerly covered with about 2 feet of water at low tide; now a dory cannot pass at low water, and an average sail-boat

cannot enter the harbor after the tide is more than half down. No yachting parties come there, and the fishermen find it unsafe to venture far out except in the best weather, lest a storm coming up when the harbor is closed by low tide, they be caught with no shelter.

This loss has caused the people interested in the harbor to feel very bitter against the "dikers," as they are called, and to hinder the success of the undertaking in every possible way. At one time they even tried to blow up the dike.

[Messrs. M. & C. A. Williams.]

Agricultural experiments on the (Marshfield) marshes have been successful. The whole marsh has not been cultivated, simply because the owners have been involved with the Commonwealth in litigation arising out of the filling of the little harbor below the marshes. In our opinion the complete success of the reclamation has been fully demonstrated, so far as any agricultural question is concerned.

[A. Savary, C. E.]

Those marshes lying directly upon the sea-coast and at the mouths of river and estuaries are of alluvial formation, varying in depth from a few inches on that part adjoining the sand dunes that separate them from the sea to several feet farther from the shore, according to the depth of the former lagoon now filled with silt and decaying vegetation. Up the rivers and at the heads of creeks, coves, and estuaries are salt marshes that were formerly fresh swamps, in which grew large trees. Stumps and other remains are still to be seen in almost complete preservation in the peaty formation. This change from swamp to tide marsh is not fully understood, though various hypotheses have been suggested. The peaty marshes are generally more favorably situated for reclamation than the others, being more easily diked, drained, and protected from the encroachments of the sea. They usually have running through them spring brooks, by means of which they can be flowed when necessary—a measure often of great utility. The alluvial marshes are generally of great extent, and as they belong to many owners of small lots, it is very difficult to get united action for improving.

To make diking successful and profitable the subject must be well considered beforehand and carried out according to a matured plan upon which all the owners should agree, and no more should be attempted than the means at disposal will allow to be well done. Any marsh from which the sea can be excluded without great expense, and in which the water can be kept 18 inches below the surface, can be profitably reclaimed. There is no better material of which to make the dike than sand, and unless the foundation is very poor no sheet-piling is necessary except at the ends of the sluice.

[Joseph Goodspeed.]

Obstacles to reclamation are found in the value of the salt hay, the expense of diking, and the time required to secure returns. The opinion is steadily gaining that reclamation would be profitable in the end. Marshes are assessed at $5 per acre, average, and adjacent upland at $20.

[Noah Hammond.]

Some twenty years ago about 40 acres were reclaimed by diking, and for a number of years produced large crops of English hay. Afterwards, owing to dissensions among the many owners, the dikes were neglected, the sea broke through, and the marshes returned to their original state.

Cranberries have been grown with fair success on several small areas of reclaimed marshes, and no doubt on some tracts, were they reclaimed, would be very profitable. Frosts hold off from 2 to 4 weeks later near the salt water than on other lands.

[Cabel Bates.]

There are, in round numbers, 20,000 acres of tide marshes in this county. The general elevation above low water is 6 to 8 feet; common rise of the tides, 7 feet; storm tides, rise from 2 to 4 feet higher. The marshes are owned in small tracts, from 5 to 10 acres as a rule. They are chiefly peaty, composed of successive growths of grasses, which decompose very slowly. On the inland and higher portion is black grass (*Juncus bulbosus*), very good for cows in milk; on the outer and lower, spear grass (*Glyceria maritima*), samphire (*Salicornia herbacea*), fox grass &c., used for feeding horned animals and bedding.

Unimproved marshes range from $5 to $75 per acre. The upland is of every grade from dead sand to the most productive soils, and values vary accordingly.

The excitement and bitter discussion connected with the diking at Green Harbor brought out all the points in bold relief before the farmers, most of whom own lots in the salt marshes. The obstacles to reclamation are the value of the natural grasses, the expense of making and maintaining dikes, and the time required to make reclaimed land productive.

The south end of this county rests on the upper end of Buzzard's Bay, which is a mosaic of bays and bayous, with points and projections of land. The north end borders Boston Bay, with much inland marsh at Hingham and Cohasset. Between these are Scituate, Marshfield, Duxbury, and Kingston, with a great extent of land submerged at the full and new moon. There may be 200 miles of meadow margin in the county.

Red-top takes most kindly to the reclaimed land, making from 2 to 3½ tons of hay per acre. Rye and oats do well, vegetables are successfully raised, and also fruit, particularly the pear. The increased production of cultivated grasses is surely diminishing the value of these unimproved marshes and their products. Black-grass meadow that would sell for $150 to $200 fifty years ago to-day will not bring more than $50 per acre.

BARNSTABLE COUNTY.

[Luther Hall.]

At East Dennis a permanent solid bridge with a sluice-way has been built within two years by the town and individuals. Most of the meadow has been set out with cranberry vines, which look well. This dike incloses about 60 acres, which could not be purchased now for less than $100 to $200 per acre.

RHODE ISLAND.

BRISTOL COUNTY.

[Henry H. Luther, town clerk, Warren.]

I know of but one small piece (4 acres) of salt marsh in this town that has been reclaimed. It was flooded two seasons with fresh water and afterward gave as large crops of hay as I ever saw on an equal area of land. A few years ago marsh land was in demand for making manure by placing it under cattle and horses and putting in hog-pens. It was found to take too long a time to decompose, and is not much used now.

Just north of the compact part of Warren is what is called Belcher's Cove, where eel grass grows from 1 to 4 feet in height and then falls down. The scum upon the water lodges on it, with other impurities. Thousands of loads are taken from the cove every summer and fall and used for manure, especially for onion land.

[Benson Beane, Barrington.]

This town contains about 600 acres of tide marsh on a level with common high water and 4 feet above low water. Storm tides rise 2 feet on the marshes. The marsh is owned in small lots, and valued at about $10 per acre; uplands, $50, $100, and $200 per acre. No marshes have been diked.

Mark H. Wood, town clerk, Barrington Centre.]

Our county (Bristol) comprises the towns of Bristol, Warren, and Barrington. I cannot learn that any considerable amount of marsh land has been reclaimed. The salt grass was long ago thought to be of value as a change of food for cattle. For this reason the marshes were sought after and became the property of a large number of people, in lots of a half acre to 2 acres each. On the tax-book they still retain a name and a value, although it would be difficult to sell a salt meadow even at a nominal price.

NEWPORT COUNTY.

[Henry J. Anthony, Portsmouth.]

Marsh land is worth about $25; adjoining upland, $75 to $150 per acre. No marshes reclaimed here.

WASHINGTON COUNTY.

[B. H. Lawton, Wickford.]

About 2,300 acres of tide marshes in this county; are generally owned in small tracts and valued at about $10 per acre; adjoining lands about $50.

Small parcels of marsh have been reclaimed, which are very productive.

CONNECTICUT.

[T. S. Gold, State statistical agent for the Department of Agriculture.]

I have replies from ten coast towns out of twenty-seven. Comparing these reports, and estimating for the intervening towns from personal knowledge, I report for this State from 18,000 to 20,000 acres of tidal lands, mostly known as "salt meadow." Black grass is the best they produce, and as hay is valued at one-half or two-thirds the price of upland hay.

NEW LONDON COUNTY.

[J. L. Morgan, Groton.]

This town contains about 2,000 acres of tide marshes, which are owned generally in small tracts. Marsh is taxed at $10 and upland at $15 per acre. Do not think any has been reclaimed.

An account by Rev. William Clift of Hon. James A. Bill's attempt at reclamation was published in the Agriculture Report of the Patent Office for 1861. It has been understood that Mr. Bill's expectations were not realized, and he has, by request, furnished a statement, from which the following extracts are taken:

[Hon. James A. Bill.]

Yours at hand making inquiries about reclamation of salt marshes along the coast, particularly my expenditure in that line, and with some twenty-six queries about tidal marshes, which I don't feel wholly competent to answer. Will, however, say that many years since the idea came to my mind to reclaim a salt marsh in this town (Lyme) some 8 miles from the mouth of the Connecticut River, it being then covered with blue grass, three-square, &c., that made fair fodder for young stock. I made a dike across the lower end, it being a narrow passage between two bluffs, with flume and tide-gates, that thoroughly drained and kept the meadow above dry.

I caused the meadow to be thoroughly ditched around the border, throwing the mud upon the outside for a bank and fence. I then cut a ditch through the center, and various cross ditches, to thoroughly drain the meadow. For a few years I had a nice field of blue-top grass, equal to anything on my highlands, but it soon began to change, and a joint grass, so called, with very woody stalk, came in. This was worthless for fodder, and the meadow became a failure as a grass field.

The next project was cranberry culture. I cut the turf into blocks, pulled out roots and wheeled all off the meadow, paid $1,800 for portable cars and tracks, worked seventy-five men three years, spent $30,000 principal, and the whole thing was again a total failure.

And now, after expending $40,000 clean money in the two projects, first a hay field, then a cranberry bog, I don't feel like saying one word to induce others to fool away their money upon those old, worthless salt meadows. Not one of them but has been and will continue to be a failure, although flaming articles may be written about them if visited at the time Rev. Mr. Clift did mine, twenty-five years ago. (See Agricultural Report Patent Office, 1861.)

These salt marshes may answer to cut a poor quality of hay that will just keep life in an animal through the winter, but they cannot be reclaimed or benefited by improvement.

MIDDLESEX COUNTY.

[Charles A. Sill.]

A marsh of 7 acres lying on the sound was diked and bore large crops of timothy and red-top. The dike has since been neglected, and the meadow has lost all its original improvement.

NEW HAVEN COUNTY.

About 700 acres of tide marsh in Madison are assessed at $20 and worth about $25 per acre. None of it has been diked. The marshes are all salt and soft, and at present values are thought to give better returns on the investment than other lands.

FAIRFIELD COUNTY.

[George A. Hoyt.]

I have made some examination of salt-marsh lands on the shore of Stamford, and am of the opinion that of some 400 or 500 acres of such lands less than 5 acres have been reclaimed, which would seem to show that it has not been thought profitable to go to the expense of building dikes. Salt-marsh lands have very little value in their normal state, hardly paying the cost of mowing the grass for feed.

[F. S. Avery.]

We estimate the marshes in our town at 2,500 acres. They are not on the sound, but always on some creek or river, where no surf rolls. They are taxed at about $10 per acre, and that is about the average cash value.

There have been some attempts at diking on a small scale, but none have succeeded. All dikes have been allowed to break through and wash away.

[William J. Jennings.]

The salt marshes along our shore have a value for agricultural purposes equal to 50 per cent. of the value of the uplands adjoining; they require no manure and the taxes on them are light. Our salt marshes produce from 1 to 2 tons of hay per acre. When timothy hay brings $20 per ton this brings $12. So the inducement to risk money on their improvement is not great. And, again, these marshes are owned in small sections by many men, and it would be very difficult to bring all to feel alike, even if success seemed probable. And, besides, at the outlets of many of these marshes are tide-mills that have rights which it would be hard and perhaps unjust to divest them of.

NEW YORK.

[F. D. Curtis, State statistical Agent for the Department of Agriculture.]

The salt-water marshes of the State of New York are located in the counties of Richmond, which embraces Staten Island, Westchester, which borders Long Island Sound, and Kings, Queens, and Suffolk, on Long Island. The Jamaica Marsh, in Queens County, bordering Jamaica Bay, the most extensive in the State, comprises several thousand acres. A portion of this marsh is mowed annually. The Flushing Marsh, on the north side of the island, contains 1,000 acres, and is drained by a navigable creek. Separated from this marsh by the village of Flushing there is another, containing 550 acres, which has been reclaimed and now produces crops of corn and vegetables. About five years ago a commission was appointed, under the general drainage law of the State, to drain this marsh. The causeways were used as dikes, and in these imbankments flood-gates were placed, which drain from 6 to 8 feet below the surface of the meadow.

The Marsh Land Drainage Company was formed several years ago, under a special law of the State, which proposed to authorize the reclamation of all salt marshes in the State, and charge the cost thereof on the owners of the land. Work begun by this company on the Flushing Marsh was stopped by an injunction, as it would have interfered with the navigation of the creek. The law was afterwards declared unconstitutional.

In Suffolk County, extending over the eastern portion of Long Island, salt marshes are found along both coasts (sound and ocean), but no effort has been made to reclaim them. Where it is possible these marshes are mowed with scythes for the salt hay.

RICHMOND COUNTY.

[J. J. Corson.]

There are about 5,000 acres of tide marshes in Richmond County. The general elevation above low water is about 5 feet, and the common rise of the tides 5 to 6 feet; storm tides rise 2 to 3 feet higher. The marshes are generally owned in small tracts. They are peaty from 1 to 17 feet deep. The vegetation is salt grass, of two varieties, known as black grass and fox grass. Cattle and horses are wintered upon it. The marshes are worth about $15 and adjoining upland $100 per acre.

It is not considered possible to reclaim the marshes, and with the exception of some little points extending inland and immediately adjoining the uplands, no attempts have been made. The reclaimed marshes in New Jersey are of an entirely different nature from those of Richmond County. The diking out of the tide water would result in the destruction of the sod formed by the strong roots of salt grass, and the land would become an impassable marsh. A few years back a bill was passed by our State legislature giving a company the right to dike and reclaim these lands, but so bitter was the opposition of the owners that the work was never attempted.

KINGS COUNTY.

[J. V. Van Pelt.]

About 2,200 acres of tide marshes in Kings County are 6 feet above low water. The common rise of the tides is 4 feet 9 inches, and storm

tides rise 3 to 4 feet higher. Much of the meadow is on Coney Island and in the immediate vicinity, and is being filled in gradually.

[R. L. Van Kleek.]

The marshes are of peaty formation. The chief product is salt hay, mostly used for packing. The value per acre of such lands is from $10 upwards. Excepting two or three acres diked for cranberries, no effort has been made to reclaim these lands.

QUEENS COUNTY.

[A. S. Smith, Merrick.]

The marshes here are 4 to 5 feet above low water. Ordinary tides rise about 4 feet and the *highest* storm tides double their height; but these rarely occur. The marshes are peaty, generally owned in small tracts, and valued at $5 to $25 per acre. Their natural growth is black grass and other salt grasses, which are cut and cured to feed cattle.

The rise from the bay is very gradual, and a high storm tide runs over much of the upland. The damage depends on the state of soil. If frozen or full of fresh water it is light, but if dry it absorbs much salt, which remains a long time. The object I had in view in diking was to keep the tide off the upland; but I find it almost impossible to keep the banks from damage by muskrats and the sluices from being choked with drift.

SUFFOLK COUNTY.

[Jonathan Sammis, C. E.]

There are from 5,000 to 10,000 acres of tide marshes in Suffolk County, including both sides of the Great South Bay. Their general elevation above low water is about 2 feet; common rise of the tides, 12 inches. Storm tides occasionally overflow the meadows 2 feet. On the mainland side of bay the marshes are owned in parcels of 5 to 20 acres; on the ocean side mostly by the township, and the grass sold at auction each autumn. The meadows have a strong turf that will hold a team and wagon, beneath that a soft mud ranging from 4 to 6 feet in depth, then hard sand and gravel. There is a spontaneous growth of sedge, black and salt grass, used for fodder and bedding for stock. The intrinsic value of the marshes for grass is about $20 per acre, but on desirable water fronts from $100 to $200 and upwards. Upland along the south side of Suffolk County is worth from $500 to $1,000, and in some localities more, for residences.

The south side of this island, from 6 to 8 miles back from tide water, is quite flat, having a grade from 5 to 10 feet per mile to the hills in the middle of the island. The flat portion is a yellow sandy loam from 1 foot to 4 feet, at which depth sand and gravel are found, with slight patches of clay in the middle and eastern part. In the western part of Long Island more clay is found, making a water-bearing table in certain localities. Long Island has been noted for its numerous small streams of pure water emptying into the Great South Bay. By reason of denuding the island of its pine forests, draining swamps, &c., the water supply, it is estimated, has fallen off 50 per cent. in fifty years, greatly endangering the outlets to the ocean; hence the tenacity of the people for the safety of navigation, fisheries, &c., and the opposition to turning the streams from the bay into Brooklyn.

NEW JERSEY.

MIDDLESEX COUNTY.

Middlesex County has 7,355 acres* of tide marsh on Raritan River and Bay and the small streams emptying into them. Most of the marshes are at a sufficient elevation above low water to allow good drainage, and are not subject to the most destructive storm tides, but some on the Raritan River are flooded by freshets to such depth that diking would be very costly. Notwithstanding their advantages of location these marshes all remain unimproved. Their natural grasses are pastured, or mowed for winter feed and packing.

MONMOUTH COUNTY.

The tide marshes of Monmouth County amount to 5,958 acres. They are found mainly on the shores of the bays south of Staten Island and on the ocean coast. Excepting comparatively small areas, they are unimproved salt marshes, and range in value from $3 per acre upwards.

[W. V. Wilson.]

The vegetation of the marshes is black grass and sedge, which are used for pasture and mowed for hay. Sedge is fine for sheep when cured. The marshes are valued at $10 to $20 and adjoining upland $100 to $150 per acre.

The nearest approach to reclamation in this vicinity is in the form of a ditch bank or dike which I have thrown up to protect my uplands. In this way some spots have been reclaimed. There are no insuperable difficulties in the way of reclamation, and at times there is much talk of attempting it.

[Rufus Ogden.]

There is much land uncultivated which is not affected by the tides, making it unnecessary to reclaim the marshes. Salt hay is in fair and increasing demand at $5 to $10 per ton. The subject of reclamation has had little serious attention.

[William S. Sneden.]

The principal obstacle to diking is the violence of northeast storms during spring tides. The few dikes built have generally been abandoned on account of muskrats.

OCEAN COUNTY.

The marshes of Ocean County are sheltered by a sandy beach extending the whole length of the county outside of Barnegat Bay. In a distance of 40 miles there is but a single inlet, and consequently the range of ordinary tides in the bay does not much exceed 2 feet at any place,

*Areas of tide marshes for New Jersey are from the geological survey of New Jersey.

the average being much less, and storm tides rarely reach more than 4 feet above low water. The marshes being, as a rule, at or near the level of mean high water, are not at a sufficient elevation to admit of thorough drainage through sluices, and can be perfectly reclaimed only by the use of pumping machinery. Nevertheless very great improvement might be effected by low dikes and sluices without pumping.

The marshes of the county aggregate 31,155 acres, and in their unimproved condition are valued at $1 to $20 per acre.

[William P. Haywood.]

Very little has been attempted towards reclaiming our marshes. Muskrats have counteracted the unscientific efforts made, and abandonment of the banks is the invariable result. Of late years the demand for salt hay for packing has been increasing, and the remuneration is sufficient to satisfy the owners, who do not care to trouble themselves about expensive improvements. That reclamation of our salt marshes would bring into cultivation the best lands in our State is beyond all doubt, but the indolence of the owners will prevent in this generation such desirable results. We have ample laws regulating ditching and diking by companies, but as the enforcement of these laws would compel the poor man to defray his portion of the expense, or have his land sold in case he could not do so, they remain a dead letter. In the upper part of Ocean County the conditions for reclaiming salt marshes are more favorable than here.

[Abm. C. B. Havens.]

The presumption is that some portions of these lands might be reclaimed, while others, in consequence of their porous nature, would allow the tide to rise *through* them to the surface, in which case dikes would be of little use. Some of these marshes above the flow of *salt* tides are our best and most productive natural cranberry bogs, worth (according to the compactness of vines) from $100 to $5,000 per acre; at least they pay a remunerative interest on these prices. The shores of Metedeconk River and the Beaver Dam Creeks are especially productive and very valuable.

[B. F. Holmes.]

The bay in front of Barnegat Inlet is 5 miles wide. Sometimes it freezes over, and, breaking up in a northeast storm, sweeps everything before it. It would be impossible to make a dike stand.

[Calvin C. Havens.]

The meadows and near uplands are so infested with flies and musquitoes that it is almost impossible to keep cattle on them.

ATLANTIC COUNTY.

[John V. Conover.]

The general elevation of the marshes above low water is 4 feet, and the common rise of the tides the same. The highest known storm tides here were about 6 feet above ordinary high water. A great deal of the marsh land belongs to the State—not taken up, and in all proba-

bility never will be. Marsh is continually forming in certain parts of the bays—first a mud bank, which in a short time is covered with vegetation. A very rough grass or a branching weed, known here as pickle weed, covers the marshes, but near the uplands a better quality of grass grows, which is used to feed stock when there is a scarcity of fresh hay; most of it is poor stuff. The marshes vary in value from zero to $20; very little is worth more than $5 and the major part is of no value. That adjoining upland is most valuable.

Our county extends from Great Egg Harbor or Mullica River on the north to Little Egg Harbor on the south, a distance of about 20 miles, and the marsh between upland and beach averages 6 miles. We allow two-thirds of this to be marsh and one-third water. This with the marsh along the rivers will amount to near 70,000 acres. (The geological survey of New Jersey gives 38,003 acres.)

The formation of the deposit is soft like pulp. Animals can feed only where a heavy growth of grass covers it. Should this be removed a man would sink to his arm-pits in places. It is very deep. The West Jersey and Atlantic City Railroad drove piles 30 feet long, three in length, without finding anything solid. It is my opinion that it will be impossible to reclaim any except a very narrow strip near upland, say 100 feet wide.

[D. S. Blackman.]

Elevation of the marshes above low water, 3½ feet; common rise of the tides, 3 feet; storm tides rise in extreme cases 2 feet higher. Marshes are worth from $3 to $20 per acre, according to situation and productiveness. None diked within fifty years, except in very small lots. The main trouble is the muskrats. When their *fur* is at a low price they increase wonderfully. Our meadows are not worthless. Salt and black-grass hay sells readily in Atlantic City and to the German farmers, and much is shipped to Philadelphia and the glass works for packing. Some acres net $5 to $6, clear of all expense.

Seventy-five years ago a marsh of some 200 acres on Nacut Creek, a tributary of Little Egg Harbor River, was reclaimed, and all the cereals then cultivated thrived wonderfully, but from disagreement in the company the embankments were allowed to go down.

[General S. G. Burbridge.]

Some years ago 70 acres near Estelville were diked and used for a meadow, the grass growing much later than on upland; also a tract near May's Landing, on which corn was grown with good success.

Where attempts to reclaim failed, the causes were lack of means and energy, especially the latter. Nothing will be done by the present owners. A new class of people must come in. The muskrats have done much damage to banks, but they are fast disappearing. Timothy grows finely after cultivating for one year with corn, oats, or other grain, making 4 to 5 tons per acre.

Much of the marsh in this county is on the Egg Harbor and Tuckahoe Rivers. In my opinion this could be reclaimed. There is a large body of marsh between Atlantic City and the highlands, some 6 miles in breadth; much of this could be reclaimed.

CAPE MAY COUNTY.

The tide marshes of Cape May County, along the ocean and bay shores and inland along the creeks, amount to 58,824 acres. Very little diking has been done in this county, though there are instances of marked suc-

cess in the northwestern part along streams which empty into Delaware Bay. The marshes there do not differ in essential features from those in Cumberland and Salem Counties, which have long been cultivated with great profit.

CUMBERLAND COUNTY.

Maurice River and Cohansey Creek, the principal streams of Cumberland County, are skirted by tide marshes far into the interior of the county. Near the bay the marshes are salt, but farther up the water is only brackish and then for many miles entirely fresh. Large areas of these river marshes have been diked for many years, and their value is well if not widely known.

[Daniel Harris.]

The owners of our tide marshes are satisfied with the success and profit that have attended reclamation. The diked marshes yield from 60 to 100 bushels of shelled corn per acre, without manure. The main trouble is that many owners fail to keep their portions of the bank and their sluices in good repair, and in consequence the land fails to produce as it otherwise would.

SALEM COUNTY.

Salem County has 28,602 acres of tide marshes on the Delaware River and creeks emptying into it. The best of these marshes are diked, and have been for many years the most remunerative lands in the county. They are valued in some cases as high as $200 per acre.

GLOUCESTER COUNTY.

Gloucester County has 9,958 acres of tide marsh, all fresh.

PENNSYLVANIA.

[Edgar N. Black, Black's Island.]

There are about 20,000 acres of marsh and embanked meadow in Pennsylvania below Philadelphia, and probably 4,000 acres above. Perhaps two-thirds of all is reclaimed. Some tracts were diked by the earliest settlers of this (Delaware) county. As much was done during the last century as has been since.

The value of the marsh before banking was nominal, say from $1 to $10 per acre. The present value of banked lands for farming is from $50 to $200 per acre, and the cost of reclaiming and improving about the the same.

The management of meadows by incorporated companies is generally satisfactory. Of course in some cases amendments would be desirable, which I suppose could be obtained, as with the charters of all corporations. As public streams have to be cut off, and to effect identity of interest, a legislative enactment is necessarily required.

Dredges, as a rule, where they can be operated, are so much cheaper

and more effective than hand labor it seems folly to institute a comparison. It is altogether impracticable to put up a bank by hand that will master the tide on the Delaware as it should.

"Can you secure ample drainage, say for corn, on meadows 3 feet above mean low water?" Most certainly, if you break up all influx from the river during flood tide; as a rule sluices are defective.

"What are the principal difficulties you have to contend with on your banked lands?" With a dredge where required, the banks liberally faced with stone, and the sluice arrangements perfect, the result is *perfection itself.* Lands in subjection as above are affected far less than upland either by drought or rain.

I cultivate potatoes, corn, Hungarian grass, timothy (for hay and pasture), and rye. I prefer corn first after a stiff sod, then potatoes, then rye or timothy. The land should be free of much grass and in good tilth for Hungarian or timothy to flourish. When needed, both manure and lime show excellent results, but the necessity for them is not one-tenth so great as on uplands.

I get 2 tons of hay per acre and 50 to 60 bushels of corn where the land is dry enough. Oats are apt to grow too much to straw and lodge; hence are little sown. Rye is much more valued, and on our dry meadows produces excellent crops, 20 to 30 bushels per acre, and 2 tons and more of straw. I candidly believe that with the exclusion of all tide water any vegetation of this climate will grow here. As it is, many kinds of trees, as soon as their roots reach the wet subsoil, stop growing. This you may say of all fruit trees, of the walnut, and probably one-half of the forest trees. They do not die, but stop growing.

I have 1,000 acres under dike. Heretofore farming has not paid, there has been so much loss from overflow, &c. With the dredge, which has been used only ten or twelve years, the prospect is far better. In fact, just at this time we are going through a revolution which I think will terminate most favorably. I am speaking more particularly of our meadows in the Kingsessing and Tinicum Meadow Company's, my own, and the Martin's Bar Meadow Company's lands, on the Delaware. I fancy but little improvement has been effected over former times, as the use of the dredge has by no means become universal.

DELAWARE.

[J. T. Budd, State statistical agent for the Department of Agriculture.]

The tide-marsh lands on the Delaware River and its tributaries in this State are classified as "blue mud," "horse-dung," and "cat-tail," and rank in value as named.

The "blue mud," a deposit of mud upon white clay, is very solid, easily ditched and banked, and with a liberal dressing of stone lime—from 50 to 75 bushels per acre—produces corn, wheat, and timothy abundantly.

It is a custom, where these marsh lands give indications of becoming poor, to cut the banks, and in from five to seven years the deposit of silt from the tide water fills from 18 inches to 2 feet. The banks are then repaired, and the marshes limed and again cultivated. They are usually valued at $100 per acre.

The "horse-dung" marshes are lower, often underlaid with sand or soft mud, and cost all they are worth to reclaim them. Oftentimes wind-mills or steam-engines are required to pump out the water. They

suffer severely from droughts, and the soil, being very friable, blows away. In some instances if set on fire they burn to ashes. They are valued at from $30 to $50 per acre.

The "cat-tail" marshes (producing the plant of that name) are near low-water mark. It is impossble to drain them by sluices, and, being underlaid with a soft, oozing mud, no foundation for a steam-pump or wind-mill can be had without piling. When reclaimed the mud is hard, sour, and unproductive. They are worthless.

The marshes on the Delaware have been reclaimed at an average cost in New Castle County of $100 per acre, and are growing 30 to 40 bushels of wheat, 60 to 75 bushels of corn, and 1½ to 2½ tons of timothy per acre.

In Kent County there are large bodies of reclaimable marsh now yielding salt hay, which finds a market at $5 per ton at glass works and for bedding stock and use in street-cars, &c. These marshes are generally of the class first named. One hundred thousand acres in the counties of Kent and Sussex, that are now malarial pests, breeding disease and mosquitoes, might be reclaimed and made valuable land.

In addition to questions answered as above by Mr. Budd, several others were afterwards submitted, which, with his answers, are here given:

Question. An attempt at the reclamation of a considerable tract, in which expensive pumping machinery was used, was made in New Castle County some twelve years ago. Was the attempt successful? Is the land now drained by pumping, and what crops are raised? If the attempt failed, what was the cause of the failure?

Answer. The tract of marsh was (and is now) reclaimed and a steam suction-pump erected, the design being to abandon sluices, lift the water over the guard-banks, and discharge it into the Delaware River; but the surface water from a large area of back country was so great that the pump was found insufficient and abandoned. Then sluices were placed in the banks, upon the theory that they should be narrow and the bottom below low-water mark. These proved to be useless and were practically abandoned. The present all-sufficient sluices are *wide* (the bottoms on a level with ordinary low water), thus enabling a free discharge from the first of ebb tide. These sluices, which have been used several years, are so broad that even the accumulated water after a strong northeast wind for several days is soon discharged when the ebb-tides permit.

Mr. A. Colburn uses a "Turkish wheel," modeled from the large wheel used at Chesapeake City, Md., to lift water into the Chesapeake and Delaware Canal. It lifts by buckets at the rim, and the water is discharged at the hub or shaft, upon both sides, and conducted by troughs or water-ways to the ditch. This wheel is driven by an engine of 10 horse-power. Upon the higher portions of his tract, corn, wheat, oats, clover, and timothy are successfully raised, and the lower portions produce coarse grasses and pasture for cattle and sheep.

Question. What has been the most common cause of failure?

Answer. A mistaken economy, in not constructing the banks of sufficient height and base to guard against extraordinary storms, has been the most frequent cause of failure.

Question. Are pumps used in draining operations recently planned, and, if so, what kind?

Answer. I know of no pumps except the wheel mentioned in reply

first. The usual method of venting the water is through sluices and gates.

Question. Are iron plates or other devices used in dikes to prevent depredations by muskrats?

Answer. Iron plates are unknown, and would be too expensive. To protect against "rats" many banks are sheathed with heavy planks, double thickness and joints broken. These are every way satisfactory and secure.

Question. Is there a subsidence of tidal marshes in Delaware to any such extent as to imperil the dikes or interfere with drainage?*

Answer. Newly reclaimed marsh land settles about 2 inches for every foot of silt deposit. Nearly all our marsh banks are made by throwing up the mud from the inside, leaving what is known as a guard-ditch. After years of cultivation the banks are cut and the tides permitted to overflow the meadows, depositing with every flood tide silt or mud, and frequently making 12 inches per annum. It generally requires about seven years to raise these lands as high as they will get, when the banks are rebuilt and they are limed and put in corn, or grass seed (orchard) is sown upon them at once.

Question. Which are the most valuable, salt or fresh tidal marshes, and is there any difference in the cost of reclamation?

Answer. Salt marshes, after reclamation, freshen by rains and surface draining. They do not throw off as much malaria as fresh-water marshes, and are generally deemed the more valuable. There is no difference of cost in reclamation by reason of fresh or salt water.†

Question. Were the submerged and marsh lands included in the original surveys, and are they held by the owners of adjoining uplands, so that dikes can be constructed without reference to riparian commissioners or other officers representing vested rights of the State?

Answer. All land-owners upon water-courses assert the right to reclaim as much marsh as they desire, and I know of no authority to prevent it. Large bodies of marsh land are owned and improved by corporations created by special acts of our legislature, with power to lay and collect taxes to be used in reclaiming, repairing banks, ditching, &c., and enforcing certain penalties upon members or stockholders for non-compliance with by-laws. Each acre or share is represented by a vote. These corporations often wrangle about cutting and repairing banks, ditching, &c.

Question. Are sections where the marshes have been reclaimed less subject to malarial diseases than before the improvements were made?

Answer. It is generally supposed that they are more healthy, but owners differ. When they are first reclaimed, and until sweetened by frosts, rain, &., persons living near suffer from chills and fevers and mild types of typhoids. After they are under cultivation malaria is not complained of.

Question. What effect has the diking of marshes had on the navigation of streams?

Answer. [Mr. Budd cites opinions to the effect that no unfavorable results have followed or are likely to follow.]

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* This question was intended to refer to a supposed general subsidence of the coast region, rather than to such settling as naturally results from decomposition. If the former is a fact, the most diligent inquiry has failed to establish it beyond doubt. At any rate, whatever theoretical interest may attach to the question, it has no appreciable practical value in its relation to reclamation.

† It is understood that in dredging operations a decided preference is shown for fresh water, and that the cost of such work is less than in salt water. The reasons are obvious.

Question. What hinders the more rapid improvement of marsh lands in your State?

Answer. The want of co-operation among marsh-owners and lack of funds. When reclaimed these marshes remain rich for many years, and are kept safe from overflow with very little watchfulness.

Question. You estimate the reclaimable marshes, mainly of the blue-mud class, in Kent and Sussex Counties at 100,000 acres. Will you please give, *by counties*, an approximation of the areas of the three classes of marshes, improved and unimproved, the areas of such as have been reclaimed, and addresses of the owners of one or more of the principal improvements in each county?

Answer. It is impossible to accurately give the acreage of blue-mud marsh in the several counties. I think a close approximation would be:

County.	Reclaimed.	Unreclaimed.
	Acres.	*Acres.*
New Castle	10,000	15,000
Kent	5,000	25,000
Sussex	3,000	50,000

	Per cent.
New Castle marshes:	
Blue mud or reed	75
Peat and cat-tail	25
Kent marshes:	
Blue mud or reed	50
Peat (or horse) and cat-tail	50
Sussex marshes:	
Blue mud or reed	10
Peat and cat-tail	90

I am indebted to Messrs. William Reybold, William Beck, and A Colburn for much information, as these gentlemen have had very extensive experience and great success in reclaiming lands.

NEW CASTLE COUNTY.

[A. Colburn.]

The soil of the embanked lands along the river in the vicinity of Delaware City is what we term blue mud. It is formed of sediment from the river, and reeds, flag, and other water grasses, of which there is a rank annual growth on the river shore. This soil varies in depth from 1 foot to 30 feet. An excavation to the depth of 12 feet showed no difference in the nature of the soil. Piling was then driven 20 feet deeper without finding bottom. Soundings in other places show blue mud from 6 inches to 2 feet, then 2 to 4 feet of black muck or peat, which is nothing more than partially decayed sea-weed. This is very light and will readily float on water. Next is sea-weed in a perfect state of preservation, to the depth of several feet, resting on sand or gravel, which indicates sea-bottom.

Our reclaimed lands vary from 2 to 6 feet above low-water mark. In some sections the ground has formed so high outside that a 6-foot tide flows only to the foot of the dikes, in others the tides rise from 1 to 2½ feet on the dikes. The ordinary rise and fall of the tides is 6 feet. Eight to 9 foot tides occur during heavy easterly storms. Eleven-foot tides are recorded, but they are not frequent.

All the dikes with which I am familiar have been built with material

taken from the marsh, and it should be taken from without the inclosure. A ditch on the guard will soon fill up, while one in the meadow will always remain open. A section of bank was built by the Saint George's Marsh Company in 1879 by means of a dredge. The ditch was dug in the guard, 24 feet wide and from 10 to 20 feet deep. That ditch is now full of good mud, and should occasion require we could again dredge it out and get an equal quantity of better banking material than that excavated four years ago. The filling of the ditch is facilitated by building a stank across, leaving both ends open.

Locating the dikes is of the greatest importance. Much money has been wasted by building too near the stream. Where the dikes are washed by the sea they should be 15 to 30 rods back from low-water mark. This allows plenty of material for building and repairing, and the growth of reeds tends to prevent washing and cutting by the sea.

If a dredge is used it should be provided with an extra long arm, so that the ditch may be as far as possible from the dike.

The sluices used in this section are built of wood, about 2 feet in depth and wide enough to vent the water. If a greater width than 3 feet is required they are divided into sections about 3 feet wide, in each of which is hung a self-acting gate. The sluices are placed below low-water mark. Great care is required to prevent the water running under or over them.

The Saint George's marshes contain some 2,000 acres, and are drained by the Saint George's Creek, which also drains many thousand acres of upland, and empties through sluices into the Delaware Bay. These lands are low, and during the prevalence of easterly winds the tides do not fall low enough to allow the sluices to vent the water. A wheel was erected and driven by steam, which threw over the bank 35,000 gallons per minute, all that was claimed for it; but there was too much water, and it was abandoned. A portion of the same land, some 500 acres, was then imbanked from the creek; sluices were put in and a wheel erected for the purpose of carrying the surplus water into the creek. This wheel, which is run by an engine of 15-horse power, has 10 feet diameter, 12 feet face, and 9 inches depth of bucket, and a speed of 10 revolutions per minute. It lifts the water from 1 to 2 feet, according to the height of the water in the creek, and throws 15,000 gallons per minute. This land has no water-shed draining into it and the sluices do all the work the greater part of the year; consequently the wheel need be run but little, say two to three weeks each year. This plan of drainage has proved fairly successful. We lift the water only 1 to 2 feet, instead of 8 feet, as formerly; consequently less than one-fourth the power is required to lift an equal amount of water.

We are not obliged to embank against a wash from the sea, and as small dikes answer the purpose, the expense of building them is trifling.

Muskrats are very abundant and destructive if the dikes are left without protection. They can be protected from rats by sheet-piling. For this purpose use 1-inch boards, 4 feet long, and drive a double row, breaking the joints. If they cut through one row, they will strike the center of the board of the next row, which will stop their progress, as they cannot gnaw through the center of a board. Some 3 miles of this piling, driven two years ago, has in no place been cut through. The piling should be driven as near the foot of the dike as practicable, and the space between the piling and the dike so graded that no water can stand on it, else the rats will work in back of the piling.

The cost of building a dike, by wheeling the mud is from 10 to 18

cents per cubic yard, according to wages paid and the distance the mud must be wheeled. It can be built by a dredger for 8 to 10 cents per yard. This cost does not include sluices, sheet-piling, or stoning. The dike should be faced with stone wherever it is exposed to constant washing by the tides. The cost of ditching is about 40 cents per rod for an 8-foot ditch, and wider ditches cost in proportion.

The first thing to be done with the embanked lands is to dig ditches. Drain the marsh and the water grasses will cease growing, and rain, sun, and frost will sweeten the land. Then sow grass seed and you will soon have a good meadow. A liberal use of lime will hasten the sweetening process. After two or three years the land can be successfully cropped wherever there is good soil 18 inches deep, if water does not stand too near the surface. The smallest ditches should be dug 8 feet at the top, 4 feet at the bottom, and 4 feet deep, and as the ditches serve for fences, they should be so laid out as to make the fields desirable in size and shape where this is consistent with thorough drainage, which should always be the first consideration.

The soil, in common with all clay soils, is baked by exposure to sun and drought, and at such times it is difficult to prepare the land and put in crops; but after they have fairly commenced growing they endure drought as well as, if not better than, on the best uplands. For general farming these lands are far superior to poor or even fair uplands, but on the whole I think our best upland is preferable. By the best I mean land which will yield from 25 to 35 bushels of wheat and 50 to 65 bushels of corn per acre. Not that the upland will produce more, but crops are more certain. For instance, if the summer be cold and wet, corn will not do as well on the meadow. Wheat grows very rank, and the straw is liable to be beaten down by wind and rain, which interferes with its filing and maturing. For meadows and pastures they are superior to the best uplands.

On newly drained lands sow herd seed for the first crop, as that grass will grow on damp and sour land. When rotating crops, sow clover and timothy. The crop will be immense, but coarse and not quite so good as that raised on upland. The grass most natural here is called green grass (*Poa pratensis?*). This and white clover come in and supersede all other grasses in three to five years. Hay made from this grass is not as marketable as clover and timothy, but it makes excellent and abundant pasture. The greatest advantage high marsh has over upland is that the soil is practically inexhaustible. We have lands which have been under cultivation for more than a century, still they show no signs of exhaustion. There are no fertilizers used excepting lime, and a difference of opinion exists regarding the benefits derived from it.

The greatest benefit of the *low marshes* is gained by using them in connection with upland. They cannot be cropped, but will support cattle, and the cattle will support the upland. The 500 acres before alluded to have pastured 100 cattle all summer and furnished the principal feed for 300 the following winter. These lands not only pay, but help to make the upland profitable.

Any marsh having 1 foot or more of blue-mud soil would be profitable if reclaimed. Lands lying as low as 2 feet above low-water mark may be reclaimed and drained by sluices, providing they are located on small streams, where they are not subjected to washing by the sea and receive little or no drainage from upland. It will not pay to reclaim very low lands on large streams, unless they should be so situated that a short dike would protect a large amount of land. It is practicable to

reclaim any good marsh where the dike can be located some distance back from the stream and on ground from 4 to 6 feet above low water.

There is only one tract of good unimproved marsh in this neighborhood, and that was improved and in profitable cultivation for many years, but the dike, being in an exposed situation, was carried away by a storm, and has not yet been rebuilt, owing, it is supposed, to disagreement among the owners or to the inability of some to pay their shares of the expense. I do not know of any unsuccessful attempt to reclaim marshes in this section.

The marshes here can hardly be termed salt, as the waters of the bay are only slightly brackish. The low undiked marsh supplies very good pasture, and cattle thrive on it. Milch cows pastured on it give a little less milk than when on upland pasture, and the milk is 20 per cent. poorer in cream. If the grass is cut at the right time and properly cured it makes very good hay, and cattle wintered on it alone keep in fair condition.

This State reserves no rights in submerged lands; owners control to low-water mark.

There is no evidence of any settling in the embanked lands, and there can be no elevation unless they are again overflowed. It is fancied by some that the tides rise higher and do not fall as low as they did thirty years ago, and that consequently the sluices do not drain these low lands as effectually as they did. We think, however, that the difficulty is in the ditches and water-courses. The sluices cannot vent the water unless the water gets to them. I have seen water at the sluices 18 inches lower than at the head of the water-course, less than 1 mile away, and the sluices were then doing not more than one-third the work of which they were capable. A difference of more than 3 inches in the level within 1 mile indicates that the sluices have not been properly cleaned.

Lands covered by the tides are not considered unhealthy, neither are drained lands. If, however, the lands be only partially drained, and water be allowed to stagnate upon them, malaria will result.

[William Reybold.]

With us marsh lands are designated by the character of the soil. The best (No. 1) are called blue or gray mud meadow. Meadows of good mud, 18 inches above water in ditches, are known as high meadow. Marsh lands (No. 2) with no superincumbent blue or gray mud consist of *peat* or vegetable matter, and are generally called peat or horse-dung marsh. There is a (No. 3) marsh with soil resembling coffee-grounds, which is nearly worthless.

Nearly all the meadows in this county have been embanked. The abundance and cheapness of upland farms, and liability of marsh lands to overflow, may be considered the reasons why capital has not sought to improve marshes elsewhere.

Banks should be strong and have the protection of a guard of reed marsh next the river, or if there is no reed guard the bank must be faced with stone. It is of the first importance that no holes *always containing water* be allowed near the bank, either inside or outside. All water should run off at low tide; otherwise muskrats will at once take possession and weaken the bank with their holes.

Where banks are placed at a greater distance than one-fourth of a mile from the river, the mud of which they are constructed should come from *inside* of the bank altogether, because there is so little time between

the ebb and flood tides that an outlet a fourth of a mile long will often not empty the ponds or rod-holes, and they can be drained into the sluice drain or inside creek. On the other hand, where banks are placed near the river the mud should come fr m the *outside*, for then drainage is readily had and all the surface inside the bank can be kept for farming purposes. Only a gutter for carrying off leakage water should then be allowed at the inside foot of the bank. The more a bank is trodden by cattle the better, as it not only makes the barrier firmer, but cattle drive "fiddlers" away by filling their holes and smothering them.

On reclaimed salt-water meadows corn does not thrive until the rains have leached the salt out thoroughly, but they grow heavy crops of wheat, rye, and oats.

There has never been any decided sinking of meadows or banks, as far as I have observed, excepting such as is caused by the decay and shrinkage of peat above the water-line.

The best sluice is the one that is best in its foundation, well piled beneath the sluice and wings. The doors open and shut with the tide, and can be either of the "barn-door" or "trap-door" kind.

I think all our marsh lands were parts of original grants, and titles were made to subsequent purchasers. In New Castle County deeds always cover title to *low-water* mark. I have been informed that in Kent County deeds convey "to the water." Nearly all our meadows are controlled by marsh companies (composed of the owners) with special charters.

If, after reclamation, marshes are kept well drained, there is less of malarial disease than when not reclaimed, and the pest of musquitoes is almost done away.

What hinders the more rapid improvement of marsh lands in Delaware? Banking out rivers and venting the waters that fall upon the lands is a contest with nature, and the individual is often unequal to the task. The *State* generally not only does not assist him, but taxes his reclaimed land, in addition to the river bank-tax. The late John M. Clayton frequently said in my hearing that, as a settled principle, the State and county should never exact taxes of meadow lands.

The best high meadow is as valuable as any upland for agricultural purposes. Below the best may be found every grade of value, and some good for nothing.

[Joshua B. Fenimore.]

The ordinary vertical rise and fall of the tide here (Odessa) is 6 feet, and storm tides rise 2 feet higher. The marshes are 3 feet above low water.

The common method of treating reclaimed marshes at the first is to ditch, level up the holes, and sow herd and timothy seed. Then pasture hard, and mow after cattle to keep the rubbish down. Crops are not subject to damage from drought unless the meadow is very high. For pasture, these lands are equal to upland, if not better; for farming, not so good. Herd's grass on low meadow and timothy on high thrive best.

There are thousands of acres of good marsh unimproved.

The effect of reclamation on the health of the neighborhood has been good in all instances.

I have used open sluices with double gates, but these are objectionable, as there is much exposed wood, which decays soon. My experience is that a broad sluice, not more than 18 inches deep, bedded and piled well underneath and at the sides, is the best.

KENT COUNTY.

[Hon. J. P. Comegys.]

The legislature of this State, at the biennial session of 1859, incorporated a company with power to embank and reclaim the salt marshes between Bombay Hook Island, in this county, and the mainland. "Old Duck Creek" meandered through them, and into it emptied guts or streams, having their sources in the island on the east or in the mainland on the west. The plan pursued was to run a bank or dike from each end of the island to the mainland, and also over low places on the island, to keep out the water from the Delaware. Where the creek was crossed it was stopped, and a large sluice or waste-gate put into an artificial channel a few yards from the creek. The aim was to make the banks broad and high enough to keep out storm tides, which during some easterly gales overflow the marshes of Delaware to the depth of 2 feet and upwards. These banks were about 3 feet high on a base of 8 to 10 feet. They were made of the material at hand, chiefly the sod of the marsh, which was little more than a spongy mass of fiber. In great tides portions of the banks were sometimes lifted bodily and floated off. Still, the expense of replacing these was not great, and, save at the times of such tides (usually winter and early spring), the marshes were protected from overflow. The water in the creek was reduced to a uniform level quite 3 feet below the original high-water mark (which was near the level of the marshes), and a system of ditches drew off into the creek, as a reservoir, the water from the marshes. The consequence was they became dry, and their draining relieved the low fast land bordering upon them of its general condition of springiness, which was fatal to good cultivation.

About ten years ago I purchased 300 acres of the Bombay Hook reclaimed marshes (as they are styled) for $1,500, and expended, in ditching, seeds. cultivation, &c., about $600 more. About three years ago I sold the property for $400. Having no experience with embanked salt marshes, I supposed (as did every one else who bought) that draining them would develop a body of land of inexhaustible fertility. Some experiments in certain localities resulted in almost unexampled production. I sowed in the spring both clover and timothy seed and planted vegetables and small fruits. At the edge of the fast land, or where the solid bottom was near the surface, they did quite well, but elsewhere they died outright or withered into decay. I then found that the drained surface of the marsh had no moisture in it except when it rained and for a few hours afterwards, and that there was no relief below from salt water. Of course these conditions were inimical to vegetation. The salt grasses died out, and, where there was no stagnant water about the surface, weeds took their place. Some of these indicate good land (and that deceived many), but those of us concerned discovered that while they grew rankly in rich upland soil, the crops they crowd out in bad farming will not grow on the marshes. Of course the marshes might be relieved of the salt water by setting sluices that would empty the creek, or partially so, and deepening the guts and ditches to carry it into the emptied reservoir. I should not have sold my marsh if I had supposed this course would make them what I expected them to become when I bought. But looking at the fact, which observation made plain to me, that they consisted entirely at the surface, and as far as I could see (observing what was thrown up in cutting ditches) below it, of mere vegetable fiber, I came to the conclusion that, even if thoroughly drained, the land would be worthless for culti-

vation in grain or grass (until in the long future it became solidified by stock roaming over it), by reason of its excessive dryness and want of body. Indifferently drained as it was, the surface would yet burn almost like tinder, and my own marsh had many holes where the fire had burnt to the moisture below. In fact, there was more danger to the banks from fire than from storm tides, the latter, of a destructive nature, not occurring yearly even, whereas gunners and others were constantly imperiling the banks.

[Franklin B. Colton, general manager of the National Dredging Company, Wilmington, Del.]

In compliance with your request for a statement covering the tide marshes bordering the Delaware Bay and River and tributary waters, &c., I would say that for many years the subject of their formation, reclamation, improvement, maintenance, and value has been of great interest to me, as I have been engaged in a business closely allied.

From observation and experience I am clear that the "tide marshes," or "river meadows," as they are called in this vicinity, may be made the most valuable, safe, and reliable lands for farming, trucking, gardening, &c., and also be rendered entirely healthful for the occupants.

Such lands on the Delaware as are now embanked have been reclaimed (until within a few years) piece meal, by hand. The material for banks (say 12 feet wide at base, 3 at top, and 6 to 8 feet high) was taken from the marsh on either side, on the outer or water side leaving irregular sinks or rod-holes, and on the inner or land side a ditch, commonly called "leak-water ditch." Before the days of steam machinery this plan of banking was excusable, but should now be abandoned, and as far as possible the inner ditch should be filled to at least the height of the land inclosed. Beside weakening the original foundation for the imbankment by cutting the surface turf or crust, the ditch becomes a harbor for rats, that burrow from thence into and through the banks, causing leaks, breaches, and "blow-outs." The small dimensions of the old hand-made banks rendered them insecure, and they required constant watching and repairs. The marsh lands are controlled and managed largely by incorporated companies, with managers who levy tax per acre as may be required for the making or maintaining of banks, sluices, and ditches for the general good.

A custom prevailed among the "old settlers" that I am convinced was detrimental to their best interests, *i. e.*, cutting ditches for boundaries, to serve in place of fences, in addition to ordinary drainage and main-trunk ditches. With large, tight embankments and good sluice-gates very few ditches are required in ordinary situated marshes, and, as a rule, the fewer ditches the better.

In some cases a ditch is necessary at or near the junction of the upland and marsh to cut off springs; otherwise one good ditch will be sufficient for a tract of 100 to 500 acres. Ditches made by machinery are better and cheaper than the common ditches made by hand. The latter require to be scoured or deepened at least once every two years, by reason of the rapid growth of rushes, reeds, docks, &c., that obstruct the flow of water and fill the ditch. Ditches can be made so deep by machinery that vegetation will not take root; therefore shoaling is very slow and the water flows freely to the sluice-gates.

Automatic sluices are generally used in this vicinity; but, as a rule, they are not so well constructed or imbedded as they should be to insure the best results or greatest durability. The best known to the writer were constructed under the direction of the late Strickland Kneas, civil engineer. These were of heavy oak and yellow-pine timber, lined

inside with heavy sheet-iron, and had double gates of boiler-plate iron. The foundation was prepared by driving piles, spaced 30 inches centers and cut off 18 inches below ordinary low water. All interstices were filled with concrete, well rammed, and this foundation covered with 3-inch plank, forming a level platform, on which the sluice trunk was placed. Sheet-piling was then driven across the face at either end and at least 4 feet from the side of the trunk, forming wings. The sluice trunk was about 18 feet wide, 40 feet long, and 30 inches deep, and had three longitudinal bulkheads or partitions, forming four openings 2 by 4 inches in the clear. The inner doors were placed about the center of the trunk, where they were exempt from interference of unauthorized or meddlesome people.

So far I have referred to the old reclaimed marshes. The value of those still lying out depends upon their location, depth, extent, and exposure. Those having the greatest depth, least frontage on tide water, and located within a reasonable distance of good markets are the most desirable for reclamation for agricultural purposes. The cost per acre depends upon the number of acres that may be shut off from the tidal waters by an imbankment of a given length. In many situations banks require facing with stone to protect them from wash caused by storms, steamboat swells, &c. Embankments may be built by machinery at from 8 to 12 cents per cubic yard. Stone facings in ordinary places and conditions cost from $10 to $15 per lineal rod of bank. From the above it will readily be seen why it would not be profitable to reclaim long, narrow strips of marsh bordering on our rivers or bay for *agricultural* purposes.

One principal reason why large areas of good marshes are allowed to remain unimproved and comparatively unproductive is that their value is little understood, especially by farmers.

Nearly all farmers who have land near the rivers either own or rent a piece of "marsh," which they value for the "rough stuff" they may cut and haul into their barn-yards, a portion of which cattle may eat and the balance form manure. Many of these large tracts are owned or controlled by a number of people, and an attempt to purchase and improve the whole will prove futile, as a rule. As yet there is a large percentage of agriculturists opposed to innovation.

There are very many admirably situated tracts of wild marsh lands on the Delaware and Chesapeake Bays and their tributaries that may be, and in the future will be, reclaimed, at a very low cost per acre, and when so reclaimed and cultivated will prove to be garden spots at once bountiful, reliable, and exhaustless.

These marshes in their unimproved condition are anything but a blessing, breeding miasma, musquitoes, and nuisances generally. All this may be remedied profitably by banking, draining, and cultivation; the stagnant pools and decaying vegetation of these pest-breeding haunts need not be tolerated.

MARYLAND.

[W. W. W. Bowie, State statistical agent for Department of Agriculture.]

The riparian laws of the State are few, and they only reflect or reiterate the general principles of common-law riparian rights. The decisions of our courts have on this subject been confined to rights between neighbors, and to the navigation and extent of ownership of water-courses and rivers between opposite counties, or citizens of those counties.

There are many large tidal marshes in the State the reclamation of which would be very beneficial to the public health and add millions to the general wealth. I know of and can learn of no individual or association "largely (or in any way) engaged in reclaiming or owning considerable tracts of reclaimed land."

Thousands of the most fertile acres could, with little comparative expense, be brought into the highest state of productive cultivation. Many persons own and pay taxes on tidal marshes which in their present condition are rather nuisances than sources of profit, but if reclaimed would be far more valuable than the adjoining cultivated upland. This is a matter which opens a wide field for investigation, and is suggestive of great wealth, now hidden and useless.

WORCESTER COUNTY.

Worcester County occupies the coast of Maryland from Delaware to Virginia, a distance of 40 miles, and is the only county in the State that touches the Atlantic. It is protected from the wash of the ocean by a sand ridge, between which and the mainland are several bays, forming a continuous water-way from one to six miles wide with but a single permanent outlet in the county to the ocean.

There are many thousand acres of tide marshes on the mainland, bay shores, and creeks, none of which have been diked. Aside from the general causes which have retarded improvement in Maryland, the tidal action in these bays is not sufficient to secure drainage through sluices for marshes that are near the level of mean high water, a condition which will preclude reclamation not based on the use of machinery for elevating the drainage water.

There are marshes in the southwestern part of the county, on the Pocomoke River, to which this objection does not apply. These are in all respects similar to marshes in the adjoining county of Somerset.

SOMERSET COUNTY.

The marshes of Somerset are estimated at twenty-five thousand acres. Unlike Worcester County, the tidal action is sufficient for drainage, but little has been done to improve the marshes and no remarkable features are presented.

The unimproved marshes are valued for taxation at 25 cents per acre.

WICOMICO COUNTY.

The marshes of Wicomico, amounting to several thousand acres, are mainly on the Nanticoke River. No reclamations are reported.

DORCHESTER COUNTY.

[J. H. Bell.]

On the Nanticoke River, from head of tide to Nanticoke Point, in Dorchester County, are 5,000 acres of tide marsh, at a general elevation

above low water of 3½ to 4 feet; the common rise of the tides is 3 to 3½ feet; the highest storm-tides rise 6 feet.

The marshes are used for grazing; none are improved. They are valued at $1 to $5 per acre, and upland from $6 to $30.

[Joseph Conway, Harrison.]

The mud flats and low marshes in this section produce wild oats, and lower down the Nanticoke River other grasses, some of them making pretty good hay for stock and packing. These marshes are of very little value; upland from $5 to $20.

Many years ago an attempt was made on the Nanticoke above Vienna to reclaim land for rice and cotton. This was abandoned, and no effort has been made for a half century or more. The majority of land owners on the lower Nanticoke and Fishing Bay busy themselves catching oysters, muskrats, and otters, and take but little interest in the improvement of land.

CAROLINE COUNTY.

There are in Caroline County 500 to 1,000 acres of tide marsh on the east shore of the Upper Choptank. This land is used only for grazing, and is valued at about $2.50 per acre, while upland is worth from $10 to $25. It is at a sufficient elevation above low water to afford perfect drainage, and is not subject to very high storm-tides. None is diked.

TALBOT COUNTY.

Talbot County has a large frontage on tide water, and contains many thousand acres of marsh land which might be reclaimed at a moderate cost, and made very valuable. Notwithstanding the favorable location, good quality, elevation above low water, and freedom from storm-tides, none has been diked.

[F. B. Baker, Easton.]

The general elevation of the marshes above low water is about 5 feet. Common tides rise about 3 feet and storm tides 2 feet higher. The marshes are generally owned in small tracts. They are chiefly alluvial 6 to 8 feet. The vegetation is a coarse cane grass, reed, flag or cattail, and rush, and is only used as spring pasture. The value of upland is about $50 per acre, adjoining marsh thrown in.

Talbot County borders on the east on the Choptank and Tuckahoe Rivers. These streams are comparatively narrow but deep. The marshes are nearly a mile wide (average), growing narrower as you ascend. The courses of the streams are serpentine, with reaches striking first one shore then the other, giving in these bends vast bodies of marsh, which are covered only by storm-tides, the average tide leaving them from 1 to 3 feet above. Cattle pasture until June, when the grasses become too rank and hard. They are burned over during winter.

With such treatment as marshes on the Delaware get they would grow immense crops of corn and timothy. They would not need high embankments. I think this marsh land equal to any in the world. It could never be worn out.

Our salt-water streams, such as Med Avon, Miles, Wye, &c., have no marsh, but solid shores that afford desirable places for residences, with salt-water luxuries and the finest fruits at hand.

KENT COUNTY.

[A. L. Cory, Fairlee.]

The owners of marshes here have no knowledge of the mode of making them valuable. I have in mind at this time a tract of marsh that with $10 per acre properly spent would be worth $100 per acre; but there is more upland in this county than is cultivated properly, and as a consequence no inclination to reclaim marshes.

CECIL COUNTY.

[William P. Colvin.]

The only land banked from the tides in this district was some 10 acres of a farm lying on the Sassafras River. On account of muskrats the owners gave it up and let the bank go down some eight or ten years ago.

The farms in this section of Maryland (first district of Cecil County) average 300 acres, and those bordering on the rivers especially are cultivated by their owners, excepting several large farms, which contain from 600 t o1,200 acres. There is upland enough, and owners pay no attention to their marshes.

HARFORD COUNTY.

[P. L. Hopper.]

There are perhaps fifteen thousand acres of tide marsh in the county. The general elevation above low water is 1 to 2½ feet. Common tides rise 3½ feet; storm tides 1 to 2 feet higher. The marshes are generally owned in large tracts. They are chiefly alluvial, with clay or sand subsoil, depth about 4 feet. The vegetation is cat-tails and coarse grasses; the latter grazed to some extent. The marshes of themselves are valueless; uplands worth from $10 to $25 dollars per acre. No marshes have been reclaimed, and no attempts ever made to my knowledge.

CALVERT COUNTY.

Calvert is a narrow county lying between the Patuxent River and Chesapeake Bay, and has tide-water on both sides, with large marsh areas. None have been diked.

PRINCE GEORGE'S COUNTY.

[Henry H. Pfeiffer.]

The marshes are formed in the bends of our rivers, and sometimes contain one thousand acres each. They are owned, usually, by those owning the lands bordering on them. They are covered by wild oats and other marsh grasses in summer, which fatten cattle very fast. When a farm adjacent to the marshes is sold the marsh land is generally given in. No marshes have been reclaimed.

CHARLES COUNTY.

[Thos. D. Stone.]

The vegetation of the marshes is fine three-edged grass, bulrushes, sedge, &c., used for grazing. Sedge is used for covering out-houses and some sold for bedding and use in street cars. Marshes are worth about $3 per acre. None have been diked.

SAINT MARY'S COUNTY.

Saint Mary's County occupies the point of the peninsula between the Lower Potomac on the south and west, and the Patuxent and Chesapeake Bay on the north and east. Being nearly surrounded by tide-water, it contains large areas of marshes, all unimproved, and presenting no features of peculiar interest.

[William J. Wathen.]

The larger marshes have usually a stream of fresh water running through them. They are covered with a coarse grass, which is valuable as pasture in early spring. I have tried peat as a fertilizer on high lands with good results.

Marshes covered with 8 inches or a foot of earth from highlands manifest extraordinary fertility.

VIRGINIA.

The counties of Accomack and Northampton, lying between Chesapeake Bay and the ocean, constitute the Eastern Shore of Virginia. They contain large areas of tide marsh, which is of little value in its present unimproved condition. The New York, Philadelphia and Norfolk Railroad makes these lands accessible, and the attention of capitalists may be directed to their improvement.

ACCOMACK COUNTY.

[E. C. Warner.]

Marshes about 5 feet above low water. Common tides rise about 3½ feet, and storm tides from 3 to 5 feet higher. Most of the marshes belong to the State, and may be bought for 10 cents per acre. They arechiefly alluvial; depth 3 to 10 feet. Vegetation principally salt flag grass and bent grass; latter cut for hay to a limited extent.

[L. B. Kellam.]

The marshes, where divided from upland, are public property. They are inhabited by the "marsh hen" and other *laying birds*, in immense numbers, and produce large quantities of muscles, used for bait in fishing.

NORTHAMPTON COUNTY.

[Abel T. Ashby, Wardtown.]

The tide marshes on the east side of this county amount to 25,000 acres. Common tides, which rise about 4 feet, do not cover them. In September, 1821, and in October, 1878, there were extraordinary storm tides, caused by tornadoes passing up the coast, which covered the marshes 4 or 5 feet. Ordinary northeast gales never fill the tide in more than 2 feet. The marshes are alluvial, 2 or 3 feet deep. They are used only for grazing. Their value is from $1 to $2 per acre. Uplands are worth from $10 to $15. Insects do not interfere seriously with stock-raising. Cattle, horses, and sheep seem to get accustomed to them. The foregoing refers exclusively to the east side of the county. There are no marshes in this county on the Chesapeake Bay. The marshes referred to lay between the upland and bays, or broad waters, just inside the chain of islands stretching along the coast. The east side of the peninsula is almost entirely free from malaria, being benefited by the pure ocean winds.

[Z. Willis.]

The owners of tide marshes—generally large landholders—do not give much attention to anything that requires so much labor as reclaiming marshes.

[C. R. Moore, Johnstown.]

One-half of the county is now in timber and the area is increasing. Labor has become scarce and unreliable. These marsh lands do not produce such salt hay as is made on the New Jersey marshes. The creeks running through them are so deep in mud that we lose cattle, by miring, every spring. In 1879 a storm tide rose 9 feet above ordinary high water—13 feet above low water—and left a deposit of blue mud, over whole fields. Storm tides generally rise from 2 to 4 feet above common high water.

FAIRFAX COUNTY.

[W. Gillingham.]

This county contains about 1,000 acres of tide marsh, all fresh. Ordinary tides rise 2½ to 3 feet, storm tides 5 to 6 feet. The marshes are 1 to 2 feet above low water. Soil consisting of mud, muck, peat, sand, gravel, and alluvial deposits of every description, is found, mud and muck intermixed with sand, predominating. The marshes are very little utilized, but some have been diked successfully, and produced good crops of hay. This is a matter of much importance, and the health of the tide-water region, in conjunction with the agricultural advantages, would justify the Government in inaugurating some system of improvement.

KING GEORGE COUNTY.

[S. M. Welch.]

There are 20,000 acres of marsh in this county, lying 3 feet above low water, but covered 1 foot by common tides and 3 feet by storm tides. Soil, alluvial, 6 to 8 feet or more. Vegetation, wild oats, flags,

reeds, and various grasses. The marshes are assessed with upland, which varies from $5 to $40. None have been reclaimed. Owners are aware of their value, but capital is wanting. They are used for early spring pastures, and hog ranges.

ESSEX COUNTY.

[Robert L. Ware.]

Twenty-five thousand acres of marsh, 3½ feet above low water, in the county. Common tides rise 33 inches, storm tides 2 feet higher, probably more. Small tracts embraced in farm surveys are assessed generally at $1 per acre, some the same as the adjoining high land. The soil is peaty. Short fine grass, rushes, and flags grow and are used for pasturage mostly, some cut for hay. Reclamation has not been considered, or at least not discussed; chief obstacle, the cost.

WESTMORELAND COUNTY.

[E. C. Claybrook.]

Marshes 1½ to 2 feet above low water; ordinary tides 2 feet; storm tides 5 to 6 feet. Marshes not used except as summer pastures; none reclaimed.

RICHMOND COUNTY.

[Dr. R. A. Belfield.]

Seven thousand acres of tide marsh in the county, 2½ feet above low water and on level with common tides. Storm tides rise 3½ feet higher. Marshes used for grazing are valued at $1 per acre. None improved.

NORTHUMBERLAND COUNTY.

With a large frontage on the Potomac River and Chesapeake Bay, there is comparatively little tide marsh; none has been reclaimed.

LANCASTER COUNTY.

[I. William Chowning.]

Diking was attempted on Towles Point farm, near Millenbeck; muskrats burrowed through dam, and improvements consequently failed.

[William Chilton.]

Marshes held in small tracts, and assessed, with upland, at $6 to 12 per acre. They grow marsh-grass, flags, wild oats, &c.—the wild oats sometimes used for hay. Owners have little information about diking. If convinced that it would pay they would make a move.

MIDDLESEX COUNTY.

[I. A. Bristow.]

Rise and fall of ordinary tides 2½ feet; of storm tides 5 feet. Average elevation of marshes above low water 3½ feet. Marshes nearly all peat; used for grazing cattle; valued at $2 per acre. No diking.

KING AND QUEEN COUNTY.

[William D. Gresham.]

About 2,000 acres marsh land on the Mattaponi. Very profiable for grazing lands, and only so used. Ordinary tides from 1 to 4 feet; storm tides 4 to 8 feet; marshes 3 to 4 feet above low water. Soil mostly peat—rarely any sand. But one instance of diking, which resulted in very large crops of corn for several years; then the dams broke and were never repaired.

GLOUCESTER COUNTY.

[William B. Taliaferro.]

Thirty-five hundred acres subject to overflow at highest tides. No fresh water rivers, all water courses (so called) being arms of the sea. Rise and fall of ordinary tides 3 feet—storm or gust tides 4 to 4½ feet; elevation of marsh 3½ feet; marshes used in grazing cattle to some extent. They sink with cultivation, and reclamation has been abandoned.

NEW KENT COUNTY.

[William. N. Tinsley.]

Ten thousand acres tide marsh; all peat; 2 feet above low water. Common tides rise and fall 2½ feet; storm tides 4 feet. Value of marshes nominal; none reclaimed. Assessed at 50 cents per acre.

HENRICO COUNTY.

[John L. Grubbs.]

The soil of my marsh and others in this vicinity is decomposed vegetable matter, covered from 3 to 12 inches by a deposit from freshets of red clay, and some sand. Elevation midway between ordinary high and low water; the tides rise 3 to 3½ feet; extraordinary and very rare storm tides 7 feet above mean low water.

I consider marsh mud the best material for constructing dikes, being soft and tenacious, and becoming very firm when dry. The ditch should be outside, as the continual presence of water inside, near the dike, would be a standing invitation to muskrats. The dike, being back from the current, is less affected by the waves from passing steamers, and the accumulation of soil on the margin outside strengthens it and furnishes material for repairs.

My sluices are made of pine plank, free of knots, 2 inches thick for bottom and top, and 3 for the sides. The dike being 24 feet at the base, I make my sluices in two sections of 15 feet, 5 feet wide and 18 inches deep. The pieces for the bottom and top are cut 5 feet long and nailed to the sides. I use one layer of plank for the bottom and two for the top. The front section of the sluice is sloped at an angle of 45 degrees to receive the tide gate, which is made of two thicknesses of 2-inch heart plank, and suspended by strong hinges and a stout iron rod. With a strong pressure of water on the inside tide gates hung at this angle would be, to some extent, automatic, but I prefer that they should not be so, and put weights on to keep them in position. They are raised with a lever by my dikeman when the tide recedes, and left open until the flood tide makes it necessary to close them. A log, small

stick, or other obstruction may happen to be in the mouth of the sluice, and the dikeman, before shutting the gate, is careful to see that the way is clear, and thus prevent the possibility of great injury to crops.

Muskrats are very destructive if not looked after and trapped or shot. My dikeman, whom I employ by the year, is furnished with game traps and a gun, and has destroyed large numbers of them. The first year I had possession of this property, six years ago, about 1,000 muskrats were caught, but the average number now is about 150. Wherever a rat-hole is found I cut the bank down to the bottom of the hole and drive down sharpened planks in the center of the bank below the point where a rat would go. In this way a considerable portion of the bank has been cored, and there is no more trouble at those points. In building a dike I would thus core it before throwing up the earth. Iron plates would of course be much better if not too expensive.

This marsh, containing 500 acres, has been in corn for more than 50 years, except during the war, when it was abandoned. Only extraordinary droughts affect it, and they very slightly. It is mostly too wet for winter crops and pasturage. I have about 100 acres in timothy on the driest portion, and have sowed red-top on a wetter portion, as an experiment. Where the land is sufficiently dry it produces very heavy crops of timothy, and the wetter portions bring enormous crops of millet.

The advantages of these lands are that they will produce very heavy crops of corn and (where sufficiently dry) hay, without the use of manures or fertilizers, and continue to do so for an almost indefinite time. The disadvantages are the occasional loss of a crop by inundation, and sometimes a partial failure to plant by reason of a very wet and backward spring. The peculiar location of this marsh, being 20 miles below Richmond, far enough below the source of our heavy freshets not to be affected by them, except such as the great floods of 1870 and 1877, and far enough from Chesapeake Bay to be but rarely affected by storm tides, renders it susceptible of profitable cultivation to a greater extent than many others. Immediately opposite, at Varina, in Henrico County (memorable as the place for the exchange of prisoners during the late war), is a marsh, similar to mine, of about 300 acres, which the owner is contemplating diking. Mine is not a salt marsh, but produces naturally, *when diked*, a coarse grass which, in conjunction with rich food, can be profitably fed to stock. The sinking of these lands under cultivation is not appreciable, and a full offset is the deposit of an occasional freshet. There is a decided improvement in the health of neighborhoods when marshes are diked and drained.

CHARLES CITY COUNTY.

[John K. Truax.]

This county contains 5,000 acres of alluvial tide marsh, 1½ to 2 feet above low water. Storm tides rise 4 feet. Rushes, sedges, wild oats, &c., and bushes grow on the marshes—all useless; value of marshes nominal; adjoining lands $5 to $10.

JAMES CITY COUNTY.

[J. H. Allen.]

Five to eleven thousand acres marsh in the county, 1 to 9 feet above low water. Rise and fall of common tides, 2½ to 7 feet in different parts of county, which fronts north on York and south on James River. Veg-

etation of little use; grazed some and some coarse hay made. Value of marshes nominal; uplands about $10. No capital for reclaiming marshes. They are rented by the season to men who trap muskrats, otters, and raccoons, shoot ducks, and kill sora. They furnish the best of food for old hogs; pigs do not fare well—their legs are too short for wading and necks too weak for rooting.

Two hundred and fifty acres, reclaimed 15 years ago, produced large crops of corn. Change of ownership, lack of means and interest, and muskrats, prevented maintenance of dikes. Marshes of great extent here might be successfully reclaimed, but there is more than enough high land to support the population, which is very small for the acreage.

YORK COUNTY.

[C. A. Post.]

About 50,000 acres along bay, rivers, and creeks. Nominal assessment. None diked—obstacles, cost of diking and storm tides. The marshes are covered with coarse grasses, aquatic plants, and shrubs, which are scarcely worth the expense of curing as feed for cattle, though used to some extent for this purpose, and as bedding for stock. The soil is made up of decayed vegetable matter—the accumulation of ages—of the shells and bones of fishes, and the sediment of sea water. The elevation of these marshes varies from an inch to a foot above ordinary high tide, and from a foot to 4 feet above low water, the tide having a range of about 3 feet. The highest storm tides reach 10 feet above ordinary low water, and then not only the marshes, but adjoining arable lands, are inundated and injured.

WARWICK COUNTY.

[I. H. Ham.]

Three thousand acres at level of common high water, and 3 to 4 feet above low water; storm tides rise 2 feet higher, sometimes more. No diking; county thinly settled and land cheap.

ELIZABETH CITY COUNTY.

[Jesse S. Jones.]

Eighteen thousand acres; none diked; used for grazing.

CHESTERFIELD COUNTY.

[T. H. Friend & Bro.]

We have 100 acres of marsh which was reclaimed about 70 years ago, and worked until the war with large profit. During the war the dike was cut, and since that time the marsh has filled in from 2 to 3 feet, leaving a portion of it out of water at ordinary tide. Marshes are of little value unless reclaimed—then $100 per acre; uplands, $20 to $25.

PRINCE GEORGE COUNTY.

[John J. Palmer.]

Four thousand acres on Appomattox and James Rivers. Diked land cultivated mainly in corn; produces as much in one crop as ordinary land in three. Little progress made in reclamation; want of capital the cause.

SURRY COUNTY.

[Edward E. Barney.]

The property in question is known as Hog Island and the Main. On this place there were ponds that had from 8 to 12 inches of water standing all the time. About 800 acres of the marsh were covered, about four times a year, with only 1 inch of water. Persons living in the vicinity have told me it is what is termed sinking or bog marsh, but I have found by careful examination, going over each acre and taking soundings, that it is all solid ground, with hard subsoil within 4 feet. I speak of this to show how little pains have been taken to know the exact condition of the marshes. The soil is composed of sand, sediment, and vegetable matter in layers. After drying thoroughly it works free and becomes like ashes. This is the character of marshes that a man would sink to his waist in before reclaiming. There seems to be from 3 to 4 feet of the above surface-soil, then a subsoil of yellow clay, containing a good deal of sand, from 2 to 8 feet, then tough, blue clay from 3 to 10 feet, then a course of sand and gravel containing good drinking water. The elevation of the marshes is from 4 to 6 inches above the average high tide, and about 3 feet above average low tide. Of course there are spots higher and others lower, and the force of the incoming tide spreads the water throughout the marshes. The muskrats working from the low marshes to the high ground make what is termed "runs," through which the water, by means of high tides and wind, is driven upon the high marsh, and not having the same force to run out as it had coming in, it remains upon the land and creates a wet marsh, which, being covered with a heavy growth of vegetation, the sun and air cannot reach to dry it up. The vertical rise and fall of ordinary tides is about 32 inches, and storm tides rise from 4 to 16 inches higher. The tide-water is salt nine months in the year. The dikes are constructed of earth taken from hills on the main land; the marsh mud would not be fit.

The dikes, which we use as roads, are made 16 feet wide on the crest; slope two to one. The average fill was 3 feet and the method of construction as follows: The line being determined, men were sent ahead to remove the grass and sod and stop muskrat holes so that when the new earth was put on it would make a solid dam. The dirt was conveyed from the mainland to the dikes by means of dump-cars. On a 2,000-foot lead, with eight cars (four loading and four going out), two mules, sixteen men in the pit, two drivers, two men at the end of the dump and one overseer, two hundred cars, containing two yards each were delivered in eleven hours. On a 3,700-foot lead, eight men in the pit, two grading track, two at the end of the dump, two drivers, one overseer, and two mules, in three consecutive days, delivered seventy-five, eighty, and ninety-three cars of two yards each; and in one day a hundred and ten cars were delivered with the same force. In crossing Hog Island

Creek three bulkheads were built of heart yellow pine to protect the dirt. The creek was 63 feet wide at the mouth, and the dike crossing here was made 80 feet on the crest, with slopes 4 to 1. On the river side, 400 feet from the bulkhead, running parallel with it, a three-row wattle fence 1,200 feet long was put in to create a fore-reach or beach by deposit from the tides, this being an extra precaution to close up the mouth of the creek. In one year the deposit has been from 8 to 20 inches in different parts. Where the dike is exposed to muskrats or the action of the tides a sheet-piling of boards 1½ inches thick and 8 feet long is driven down by a 400-pound hand pile-driver. The sheathing is put at the heel of the slope, so as to be as nearly covered as pos sible, to protect it from the action of the air.

We were compelled to get up our own sluice-gates. They are composed entirely of cast-iron and brass. We have two kinds—one automatic, the other a lock-gate, which requires the attention of a man. The whole front of the bulkhead holding the sluices is composed of cast-iron slabs 2 feet wide, 10 feet long, and ¾ of an inch thich, with lap-joints, and made to receive the sluice-gate frame. The frames for the sluices are formed by driving piles with a steam hammer, the timbers being framed to receive the cast-iron plates, which run into the bottom 2 feet, and are so tied and braced that in case the piles give way they will remain in place. The sluices are placed at average low tide and drain the land 3 feet deep. In order to drain the land below 3 feet, a steam pump and a pump run by a windmill are used. As a part of the water would have to run 4 miles we made a summit in the center of the island and draw the water both ways. We cannot depend entirely upon sluice-gates, as heavy rains are generally followed by high tides.

Muskrats and minks are very troublesome, and influenced us in deciding to reclaim all the marshes at once, as by drying the marshes they leave at once. They do not trouble us on the river or seaside.

The cost per cubic yard for dikes varies from 9 to 20 cents, depending upon the lead and the amount of dirt required at one point.

The reclaimed land after the vegetation is burnt, is plowed, and, if in condition, put into corn. The first crop is very poor, but the second year it improves 100 per cent. The crops of the first year seem to burn out, whether from drought or salt we cannot tell. The land reclaimed must be cropped with corn, &c., until it is sweetened. If seeded down too soon in grass it will run to weeds and rank grasses. Timothy, herd's, and orchard grasses thrive.

Marsh lands properly reclaimed are worth four times the value of upland. The disadvantage is the outlay so long before any profitable results are seen. They will not produce to their full extent until the third year.

There are thousands of acres in our vicinity that might be reclaimed with profit. It is only a question of dollars and cents—the sure protection of crops in wet seasons. If a man has 200 acres in corn, or to be put in corn, how much of a permanent investment he can make in machinery and cost of running it is a question for him to decide. It has been stated to us on good authority, that in former times on poorly reclaimed land, as high as 14 barrels of corn have been taken off one acre (or 140 bushels of ear-corn) on this place.

The diking of the lands has had no effect on the channel that we are aware of. The effect on health has been good.

The value of unimproved marshes can not be stated, as they are always connected with uplands, and as most of the farms on the river have marsh. I suppose the value most persons would put on the marshes

would be from $2 to $10 per acre. Uplands are worth, as indicated by sales, from $3 to $20 per acre. To reclaim the marshes requires money, time, ability, and patience, but they more than repay the cost. The subject of reclamation is so important that the United States Government could well afford to expend a large amount of money in gathering and publishing statistics, making surveys of the marshes, giving levels, and furnishing advice, by competent engineers, in regard to reclamation.

NANSEMOND COUNTY.

[John Cartwright.]

There are 2,500 acres of peaty marsh in the county owned in small tracts and valued at $5 per acre. Upland ranges from $10 to $60. Marshes near the sea produce short grass, worthless, only for grazing; higher up near fresh water it is longer, and is cut, baled, and sold for bedding stock. No marshes diked.

PRINCESS ANNE COUNTY.

[George E. Ferehee.]

The marshes of this county are of great extent, but only used for grazing and gunning; value, 25 cents and upwards. In the southeastern part of the county they are mostly fresh-water marshes now, but were a few years back salt; they empty their waters in Currituck Sound, which (formerly salt) has become brackish since the filling up of the inlet. The tide does not rise and fall along the marshes as it does on the coast, and they are more subject to overflow from heavy falls of rain than from flow of tide. Soil admitted to be of best quality. The pure salt marshes along our rivers and bays might be readily diked and drained. They are usually from 6 to 18 inches above ordinary high water.

NORTH CAROLINA.

[M. McGehee, State statistical agent for the Department of Agriculture.]

No work for reclaiming sea marshes is going on in this State. The quantity of land known here as swamp land is between 3,000 and 4,000 square miles, and the cost of reclaiming it would be trifling as compared with the cost of diking out the tides.

The following is an extract from a report submitted to the legislature at its recent session:

"Before the termination of the civil war, the valley of the Cape Fear possessed a monopoly of this (rice) crop in this State. During the war experiments proved it could be grown upon low-lying lands, up to the foot of the mountain range. The introduction of upland rice gave a still further impetus to its cultivation. This new industry—new because under conditions so different from those existing before—has now become an established and most important one. It has become a staple crop in counties where none was produced a few years ago. The county of Hyde alone produces now—if such statistics as are accessible to us may be trusted—nearly as much rice as the entire Cape Fear Valley produced before the war. Other counties have also gone largely into its culture."

CURRITUCK COUNTY.

[W. G. Granbery.]

At least one-fifth of the county is tide marsh. There are no regular tides, but they rise in violent storms several feet—3 or more. The vegetation of the marshes is bulrushes, cane, sedge, and in spots finer grazing grasses. The value of the marshes is nominal, from 50 cents to $1 per acre, excepting such as are frequented by wild fowl in fall and winter. Highlands are worth from $3 to $25 per acre. In many of the islands and marshes in Currituck Sound, upon a shift of wind from north to south or southeast, the water rises in low places long before the tide in the sound and the creeks overflows them; hence I judge that diking would be thrown away. Under the turf the foundation is miry. Cattle and hogs can pasture on them, but horses for most part cannot, and in early spring cattle frequently mire. The marshes then are what we term *rotten.*

NEW HANOVER COUNTY.

[P. Cumming & Co.]

The surface-soil on marsh lands just reclaimed to the depth of 2 or 3 inches is usually vegetable matter, held together by grass roots; below that depth it is, on water-courses, blue clay and black mud, in different proportions and to an indefinite depth. As it recedes from water-courses the land is lower and clay and mud become scarce and in places almost disappear. On salt marshes the highest spring tides overflow the higher parts to the depth of a few inches, the lower parts from 15 to 18 inches. The low water drains them from 18 to 24 inches. Elevation of surface, from 18 to 36 inches above low tides. Only one steam-pump is used in this vicinity for draining.

In timbered fresh-water lands muskrats, snakes, and cray-fish cause considerable mischief at times.

A hand at 75 cents per diem will dig 720 cubic feet of ditch in a day, and the next day construct the bank, which here should be 10 to 15 feet at base, 4 feet high, and 3 feet wide on top. The cost per acre is from $6 to $20. After diking we cut down or burn off the native growth, sow seed (rice) in drills, and put on water; then, when ready, give one or two light hoeings. This makes the land pliable for next year. After a few years' consecutive culture plows may be used with profit.

For meadows and pastures these lands compare more than favorably with uplands. Freedom from drought and the assistance of the water for working crops are the principal advantages. Rice farming (by water culture) on reclaimed marshes is generally detrimental to health.

[Fred. Kidder.]

My lands are reclaimed salt marshes, the formation being silt, and though not as stiff a clay as that of the Upper Cape Fear, is very fertile. The same soil extends down many feet.

The elevation of land above low water is about 3 feet. Ordinary tides rise upon my dikes about 1 foot, and the highest storm tides 4 to 5 feet higher. The dike is constructed of material excavated from the marsh, and the ditch from which the material for the dike is taken is without the inclosure.

I first cut a ditch, 12 by 18 inches, along the center of the base of the dike to prevent leaks. The ditch from which the mud is taken is about 20 feet from the base of the bank. This does not weaken the bank, and grass growing upon the margin acts as a breakwater. My sluices are 25 feet long, 18 inches deep, and 4 or 5 feet wide—made of 3-inch plank for sides, 1¼-inch boards for top and bottom, and a 3-inch plank running through the center. The inner end is closed by a shutter moving in a groove—the outer end by a shutter, which hangs from uprights (4 by 4 scantling) set into the trunk. The inner shutter is used when we flow our fields and wish to retain the water upon them—the outer shutter to drain and keep the tide out.

I am putting in a large rotary pump to drain my land, believing the additional draining will be of great benefit to me in planting and harvesting rice.

We are not troubled by muskrats; the snake, wood rat, and alligators are the only animals that bother us, and we use nothing to prevent them from burrowing through our banks. The cost per cubic yard of constructing dikes is 6 or 7 cents, and the average cost per acre of diking and draining marshes is about $25.

The method of treating reclaimed marshes is to burn off all trash in the spring, after having soaked the land with fresh water to rid it of salt. Some planters even hoe off before planting the first year. The crop of the first year is generally poor, but the second year we look for large returns. Never plow before the third or fourth year, as the plow will cause a growth so rank that the crop will lodge and fall with the slightest wind. No fertilizer is ever required on these lands, yet they produce after many years of cultivation 75 to 80 bushels of rice to the acre.

We always have a boundless supply of water at our control, and consequently do not suffer from droughts. I have never known any crop except rice planted on these lands with success. Corn, though it grows very luxuriantly, does not fill out well. Oats and wheat have been tried, but I cannot say successfully. Indigo was first planted upon them, but the planters gave up its cultivation for rice, which was more profitable. I have never known any grasses grown upon the marsh lands, though it is claimed they do well.

[Robert B. Wood.]

My reclaimed land is river swamp, with a surface-soil of rich mud and vegetable deposit, and subsoil of blue clay for several feet. It is about 3½ feet above low-water mark. The ordinary rise and fall of tides is about 4 feet. Storm tides rise 1½ to 2 feet higher. When kept dry these lands will produce any crops planted in this section—wheat, oats, corn, &c.—and the meadow grasses in great abundance.

Any good marsh, admitting of proper drainage can be reclaimed with profit. The effect of reclamation on the health of the neighborhood has been a great improvement.

[Navassa Guano Company, per D. MacRae.]

Our lands were timbered alluvial deposits, containing a large percentage of vegetable matter, with some loam and stiff clay; depth of soil, from 6 to 60 feet or more. The marsh lands differ mainly in never having had any growth of timber upon them. They lie from 2 to 3½ feet above low water, and from 6 to 18 inches below ordinary high water.

There is about 4 feet difference between ordinary high and ordinary low water. The highest storm tides rise about 2 feet higher than common tides.

In constructing dikes we use the adjacent materials from both sides, but in occasional cases of leaks from soft spots or burrows by muskrats, minks, blind eels, sand fiddlers, &c., sand is brought in and used successfully. An inner ditch is always cut for drainage. Before building a dike we dig a center ditch to remove all roots, &c., which are likely to cause leaks. The dike should have 2 or 3 feet of width on the top, and a slope on the inner side of about 45 degrees, and more on the outer side. We use a plain trunk, about 4 to 6 feet wide and 12 to 18 inches deep (according to acreage of the field to be drained), made of best heart pitch-pine lumber, side planks 3 inches, top and bottom 1½ inches thick.

There are no siphons used in this vicinity. One pump has been tried recently, but its success has not yet been satisfactorily proven.

Muskrats, minks, blind eels, and, in salt water, sand fiddlers give more or less trouble, but cannot be said to be destructive of dikes. Iron plates have not been tried. Occasionally boards have been driven down, edge to edge, but they soon rot away. Sand is the best material to prevent burrowing.

Dikes cost from 6 to 8 cents per cubic yard. On our lands (originally timbered) draining costs about $10 per acre; on marsh lands the cost would probably not be half so much. *Salt marshes* require inundation with fresh water, after being diked, to remove the salt, and are then cultivated in rice continuously. Crops are not subject to damage from drought. Marsh lands are much more fertile than uplands, and when thoroughly drained are better for meadows and pasturage, and are worth from four to six times as much as uplands. We are informed that timothy and herds grass succeed better than other kinds, but have never experimented with grass crops.

There are large bodies of fresh-water marshes on the Cape Fear River above Wilmington, and of salt marshes—having fresh-water streams running through them—below, within 50 miles of the city, which might be easily brought under cultivation, but for want of means and enterprise. The most common cause of failure in efforts to reclaim lands has been want of sufficient capital.

In regard to the effect of reclamation on health doctors differ, and the subject is still open for discussion. Clearing virgin swamps usually produces malaria and chills and fever, but reclaiming old rice lands or salt marshes does not, we think, affect the health of their neighborhoods more than leaving them unreclaimed, and filled with stagnant water and decaying vegetation. Many believe that the cultivation of rice is prejudicial to health in the vicinity, but as many believe otherwise.

BRUNSWICK COUNTY.

[A. M. Rieger.]

Surface of marsh 12 inches deep of decayed vegetation, after that blue clay. An ordinary high tide, which rises 4 feet, covers the surface from 2 to 4 inches; highest storm tides, 2 feet.

Muskrats injure the banks to a limited extent; snakes are more abundant, and cause some damage in way of leaks, which, if not stopped, cause breaks. Cost of dikes (depending upon the nature of the soil, and whether clear of roots and logs), from 5 to 25 cents per cubic yard. To clear the

original growth, bank and ditch, parties used to contract at $100 per acre, in preference to using their own labor.

We plant the reclaimed marshes in rice without rotation from year to year. There are fields on the river that have been in cultivation for eighty years, yielding 40 to 60 bushels of rice per acre, without any fertilizer, and they yield as much now as when first reclaimed. Rice is the principal crop, and grades the finest in the world. Unsuccessful attempts have been made with corn and cotton. Broom-corn was successful to a limited extent; also alfalfa. For meadow and pasture these lands are far superior to uplands.

There are no lands on this river that do not drain sufficiently (natural drainage) for rice culture. The fields as a general thing are not level, and when the highest part is hardly covered the lower parts have 12 inches of water. Our lands drain from 18 inches to 3½ feet. Lands draining less than 1½ feet will not make a large yield of rice. Lands adjoining the main land average 20 to 25 rods of dike per acre. Most of the rice lands in this immediate section are on an island containing about 3,000 acres. These lands drain finely, and are very fertile. Blue clay or marl lands are best for rice, and, I think, for all purposes. There is very little light land on this river, and even this will produce heavy crops of rice for several years. We improve it by allowing rest, and flowing with every tide for a year. The deposit from the growth, and sediment during freshets, soon restores the land.

You ask my opinion as to the probable profitableness of producing hay. While it has not been given a fair test, I am decidedly of opinion, judging from the luxuriant growth of timothy and clover I have seen growing on the dikes, that it would be profitable. The deleterious effects of flooding in hot weather would be avoided and the health of this section during the summer months materially improved. There are considerable unimproved marsh lands on the river that might be reclaimed with profit. The principal cause which hinders their improvement is want of capital.

The health of the neighborhood is good until the long flow is put on the rice, which is from the middle of July to the 1st of September. Then the stagnant water has much to do in causing bilious and other fevers peculiar to this section.

There is very little tide land here subject to overflow by fresh water that was not in cultivation previous to the war. About 4,000 acres were diked and in a high state of cultivation, yielding an average crop of forty bushels of rice per acre. The assessed value of such lands is from $10 to $60 per acre, according to improvements; cash value, the same. Diking is now in progress only to a limited extent; want of capital the cause.

SOUTH CAROLINA.

HORRY COUNTY.

[Thomas W. Daggett.]

On the Waccamaw River there are several tracts of swamp or marsh lands, diked and ditched, that were cultivated successfully in rice prior t 1865. The salt-water marshes have not been cultivated. The fresh-water marshes are sometimes overflowed in the winter by freshets. Dikes 6 feet high would prevent such overflow. There are large bodies of unimproved tide-water marsh lands.

GEORGETOWN COUNTY.

[S. E. Barnwell.]

I reply to inquiries on the subject of the abandoned rice lands of this county as follows: The average area of the rice plantations as formerly settled was, say, 400 rice acres and 200 of highland. The old dikes and ditches are not obliterated, and would have great value in a second reclamation of the land, as they appear to have been very carefully laid out with reference to the water level and convenience of harvesting. Of course, being in alluvial soil, they would have to be renewed.

These plantations at present have no market value, and could be bought at any price, from $2 to $5 per acre. If, however, there was any demand for them they would immediately spring to, say, $5 to $10. Under cultivation they would bring from $50 to $75.

The common field-rat and a few other animals bore the dikes somewhat and necessitate annual inspection and repairs, but not more than is generally expended on fencing highlands.

Work is mostly done by contract for the year, and costs from $200 to $250 per full hand.

The large investments in rice on the Gulf coast rather than on the Atlantic can only be accounted for by the fact that these investments were mostly changes from sugar to rice, while the planters here had to struggle on with their own small means, or with the advances from factors who were themselves dependent on others for funds. Under these circumstances, the loss of a crop (often after it was made) by the September gales would cripple the planter for the next year's operations, when perhaps with additional precautions, or a lesser gale, he would have replaced former losses and paid a good profit besides. As a rule, therefore, rice planters have not prospered (though many who are able to keep their places in good repair make $20 per acre clear profit), and the failure of these small capitalists keeps the larger ones away.

I cannot speak of the comparative salubriousness of the Gulf and Atlantic coasts, as I have no acquaintance with the former, but can say from considerable experience that while the rice fields will cause their residents to be more or less affected with malarial fevers, yet they are seldom afflicted with other diseases; and these fevers, though troublesome and weakening for a time, yield readily to treatment, and rarely terminate in death. Indeed in my own neighborhood, with a population of 1,500 within a radius of 5 miles, our only doctor has left for more prosperous but less healthy climes.

No hay is made here, but rice straw (which is cheap, but a very poor substitute) is used instead. Northern and western hay costs, delivered here, $1.25 per hundred pounds, but is little used in the rice country, and consequently the stock is all of a most inferior quality.

The county of Georgetown has large tracts of tide lands, most of which have been diked for years, and planted in rice. It was formerly a very wealthy county, in its agricultural resources, but under the free-labor system has fallen almost to bankruptcy.

The lands are admirably fitted for the use of improved machinery, but the want of skilled labor is needed. The negroes are well-behaved and willing to work in their own slothful way, but cannot be counted on in an emergency, and the reputation of the country for health (unjustly so) keeps whites away.

[Dr. James R. Sparkman.]

Tide lands in this county utilized in rice culture (formerly about 46,000 acres; at this time only 10,000 acres) are diked to exclude the water while preparing for planting, as also in harvesting, and provided with flood-gates, with the view of irrigation and water culture.

All these lands not diked are submerged by the ordinary tides, which rise and fall about 3 feet. Gale tides and freshets have a maximum elevation of 2 to 5 feet above ordinary sea tides. The ordinary rise and fall on Georgetown Bar is estimated at 5½ feet. We have no second river bottoms in this county subject to overflow either from storm tides or freshets.

In addition to the former area of rice culture above stated (about 46,000 acres), there are five to eight thousand acres of marsh lands unimproved, more than half of which could be diked and utilized with large capital, but not by the present owners. All these lands are owned by private individuals, no portion belonging to the State.

The soil is entirely alluvial, with no admixture of sand—a blue mud of unlimited depth and inexhaustible fertility. The growth on these unimproved marshes and abandoned rice lands is not utilized.

The drainage of these marsh lands at low river varies from 2 to 5 feet. They are occasionally submerged entirely (marsh growth and all) by extreme gale or storm tides; but ordinarily the vegetable growth reaches 2 to 4 feet above the average sea tides.

Concerning hay culture, no effort as yet, but many are of opinion that jute or hemp will succeed where rice culture is abandoned, and that hay will be successfully substituted on the short rivers.

These lands (all tide lands) are without a market value, there being no demand for any of them. They are assessed for State and county taxes at 50 cents to $1 per acre when uncultivated.

All our tide-land culture is at extreme low-water mark, if I may thus express the decline in the rice industry.

BERKELEY COUNTY.

[P. M. Pepper.]

Many thousand acres along the Santee River were reclaimed for rice before the late war, though it was impossible to exclude freshets, which rose 12 or 15 feet. The common tides rise 5 or 6 feet.

Marshes upon the seaboard are not valued. Former owners have, in many instances, allowed the State to confiscate them for taxes.

Marshes, salt and fresh, cover the greater part of the county.

CHARLESTON COUNTY.

[James Campbell.]

The lands I cultivate for rice are tide swamp lands, subject to overflow by freshets, and known as cypress swamp. The surface is bog or peat; the subsoil, 2 feet below, is clay.

The ordinary fall and rise of tide when there is no heavy rainfall is 4 feet; during freshets there is no fall of tide, and the rice lands are under water. My lands are about 1 foot higher than the ordinary tides.

Bottom lands used for rice culture are not generally adapted to high-

land crops, but where lands of this character have good drainage cotton and corn can be grown on them with profit.

No cultivated grasses that I know of will grow in rice lands; the water grasses are of such early and rank growth that they kill all other grasses. On the highlands adjacent to the rice fields we have Bermuda grass, which makes excellent hay. It is a spontaneous growth of some sections. Dr. St. Julian Ravenell made ten tons of hay from an acre.

Thousands of acres of unreclaimed marsh lands lie idle here; whether they can be reclaimed with profit or not I am not prepared to say.

COLLETON COUNTY.

[W. B. Gruber.]

Unimproved marshes assessed at $1; cash value, $3. Fourteen thousand acres reclaimed; assessed at $20; average cash value, $100. No diking now in progress; cause, lack of labor and capital. The cost of diking and draining is heavy, and the planters have been able to make but slight progress since the war.

[Allen C. Izard.]

River swamp lands are most valuable above salt water and below freshet mark; both will depend somewhat on the season. The safe point would be about the middle of the rice section of any of our rice rivers.

Most of the lands on this river (Combahee) have been reclaimed, but are not successful for want of means to carry out the undertaking.

I see no effect of reclamation on the health—plenty of fever from June to November; at other times the finest climate in the world.

[Joel Larisey.]

The land nearest the rivers is generally the best. The surface is black soft clay, to the depth of about 12 inches; subsoil also clay, of a lighter color and more stubborn. Our second grades, known as bay lands, are situated farther from the rivers, but subject to overflows from the tides. The soil of these lands is light, and when very dry will burn, if ignited, until overflowed by lifting the gates. The subsoil of these bay lands is generally sandy.

Lands that are covered with rushes and have no marsh grass on them cannot be reclaimed profitably. Most cases of failure in reclaiming have been on rush lands.

Where lands are reclaimed *and kept dry* the effect on health is good.

BEAUFORT COUNTY.

[H. C. Judd.]

In Saint Helena Parish, Beaufort and Saint Helena townships, are 40,000 acres of tide marsh—all State property, but about one-fifth which is covered by private grants. Marshes 7 to 9 feet above low water; mean tides, 7 feet; extreme, 10 feet. The soil is almost entirely alluvial, 1 to 5 feet deep on shell and phosphate banks.

The coarse woody grass of the unimproved marshes is cut green for cow-pens. The native cattle eat it when tender, and it is gathered for manure when dry.

The private grants are taxed on a valuation of 50 cents per acre. The uplands adjoining are the best lands in the low country, and are worth $10 minimum; often sell for $25 to $40.

No marshes have been reclaimed in these townships, but in the lower part of the county some of the best rice lands were formerly large tide marshes.

The area of Saint Helena Parish is about 230,000 acres, or ten townships, of which about 160,000 acres are arable and timbered land. Thirty thousand are covered by inlets and streams, leaving 40,000 acres, approximately, in tide marsh. Of course, in this latitude, the marsh grass is *always* somewhat green, so that at low tide we have vast surfaces of meadow-like plain, islands of green, intersected by creeks in all directions. Small tracts, comprising from 10 to 40 acres, were reclaimed from the tide marshes as far back as 1840, and the production of cotton and corn on such lands was most successful, giving large returns with very small liability to failure. In fact this is done to a small extent by a few of the colored planters now, with good results.

GEORGIA.

[J. S. Newman, State statistical agent for the Department of Agriculture.]

Much of the land devoted to rice culture previous to 1861 has been abandoned in consequence of inability of owners to control the labor necessary for profitable cultivation. While some new lands have been opened to rice culture, the number of acres abandoned considerably exceeds the number opened.

LIBERTY COUNTY.

[Charles C. Jones, jr.]

Marsh lands unreclaimed possess little value, except along the line of streams, where they may be utilized for the cultivation of rice and cotton. The adjacent upland is worth from $3 to $5 per acre. Before the war the marshes along the line of North Newport River had been largely reclaimed, and were successfully cultivated in rice and cotton. There is no difficulty in reclaiming these lands, except the want of money and reliable labor. The wide-extended salt marshes lying between the outer islands and the main are not susceptible of reclamation, except at great expense. Once properly protected they would doubtless prove very remunerative, but the vast amount of uncultivated land in the vicinity and the unreliability of the labor deter from large expenditures. As the population of the country becomes more dense these marshes will, beyond doubt, be utilized. I am familiar with what has been accomplished in New Jersey, Delaware, and some of the New England States, and there is no practical reason why the marsh lands of Georgia should not largely be reclaimed in a similar way were the necessity laid upon the population, and were the inhabitants possessed of the requisite money to defray the expense.

[James A. M. King.]

The alluvial or boggy marshes grow what is called marsh grass (*Uniola*), some of which is cut for green feed during the summer. The salt marshes are worth nothing; upland adjoining, according to position, from 25 cents to $2 per acre, or more, for improvements.

High up the North Newport or Riceboro River we own 130 acres of rich peaty land, reclaimed in 1835. After nearly fifty years of cultivation it is as fertile as ever. On the Altamaha, Ogeechee, and Savannah Rivers the large rice plantations are reclaimed river swamps and marshes, with a full supply of fresh water, and sufficient tidal action to flow and drain. Those lands are valued highly. Before the war they cost $200 per acre to put in order.

Our lower salt marshes are unavailable—too boggy for cattle to stand upon. From the mainland eastward to Saint Catherine's Island, and along the river banks inland to brackish water, the common marsh grass grows luxuriantly on fresh deposits in curves of banks; stuntedly away from the banks. Such marshes will not bear the weight of dikes and are of no use. Higher up the Newport River (which is but an arm of the sea) the marshes become firmer, and the hard or black rush grows. With the exception of small creeks, bordered with *uniola*, these rush lands can be reclaimed. They are very rich.

M'INTOSH COUNTY.

[James Walker.]

Tide land has been planted in this county for nearly a hundred years, chiefly with rice, along the Altamaha River and its outlets. Previous to the war salt marshes were used in the cultivation of sea-island cotton, which grew to perfection, yielding as much as eight hundred pounds of lint cotton to the acre. Since the war labor has been so uncontrollable that no attempt has been made on the part of land-owners to reclaim such land.

GLYNN COUNTY.

[Capt. James Postell.]

Twenty-four thousand acres of tide marsh surround Saint Simon's Island. The elevation of the marshes above low-water is about 6 feet; common rise of the tides, 8 feet 6 inches; storm tides, about 11 feet; but on one occasion, 1854, the tide rose 1 ½ feet. The vegetation is a very coarse grass, which is much relished by cattle; in fact, the marshes are about the only winter pastures we have. Marsh lands are of nominal value; uplands, from $5 to $20 per acre.

About sixty years ago Mr. Butler reclaimed a marsh island of about five hundred acres, and planted cotton. I have been told that it was a great success, producing a bale to the acre. It was abandoned on account of the low price of cotton; and fresh-water swamps higher up the river were reclaimed and cultivated in rice, which has always paid better than cotton. It is only for lack of means that our marshes are waste places. They were attracting attention before the war, and two of my neighbors had commenced diking large areas, but the war came on and the work stopped. I have seen experiments on a small scale, and in every case they have proved successful. The marsh east of the island is much higher than it was thirty years ago. Cattle could then feed only along the edges; now they go over nearly all of it.

CAMDEN COUNTY.

[Joseph Shepard.]

Estimated amount of marsh bordering the rivers and flowed by *salt* water, 30,000 acres; flowed by fresh-water tides, 26,000 acres; total tide lands along the rivers, 56,000 acres; between islands and mainland, 6,000 acres; total covered by storm tides in Camden County, 62,000 acres.

Rise and fall of ordinary tides, 6 feet; storm tides, 8 feet. The average elevation of the salt marshes above low water is about 6 feet; fresh tidal marshes about 4 feet. Soil generally peat and alluvial deposit combined. At a depth of 3 feet blue clay is often found. Thirty per cent. of the tide marshes furnish grazing for marsh tackies (small horses), cattle, and hogs, and the vegetation is good to enrich the dry land.

The land is owned by the State and private owners, about one-half by each. The value is owing to quality and location, say $1 to $2 per acre, about the same as dry land uncleared.

Some 400 acres of salt marsh have been reclaimed by diking, with favorable results, corn yielding 60 to 70 bushels per acre, and cotton producing largely.

In going up the Saint Illa River, the rice-growing section of this county, at 15 miles from its mouth the water begins to freshen, and at 25 miles becomes fresh, although the usual rise and fall of the tide is only a foot less than at the mouth of the river. At the fresh-water point the tide lands are covered with cane, cat-tail, grapevines, cypress, gum, &c., and are called river swamps. Here the rice fields commence. This land is very expensive to reclaim, but has the advantage of being free from salt water and can be flowed, which is necessary in the cultivation of rice. Three flows are usually given in raising a crop of rice: 1st. The sprout flow; 2d. The stretch flow; 3d. The harvest flow. The trunks or sluices have inner gates, worked by hand, to hold the flow on the land. In reply to your inquiry relative to rice fields once planted and now abandoned: The case is the same in this county as in sections north of this, and the reason is plain. From 1861 to 1866 all rice planting was abandoned, the dikes were broken, the ditches filled, and the fields left to bushes and vines. On return of the owners in 1866 nearly everything had to be reconstructed, and there was a great demand for labor in manufacturing lumber and naval stores, which made rice planting expensive; hence there were only about 400 acres planted in this county in 1866. From that time to this the acreage has increased yearly, until nearly 3,000 acres are in cultivation. And yet over 1,000 acres once reclaimed remain uncultivated. The yield is 40 to 60 bushels per acre in the rough. Referring to the 400 acres of salt marsh in this county reclaimed and producing 60 to 70 bushels of corn to the acre and large crops of cotton, concerning which you inquire, I have to say that this land was diked in only a few years before the war, when farmers had just begun to realize the value of the salt-marsh lands. After peace the condition was such with the few who had tried it that they could not even put their dikes and gates again in repair; and as there are very few forehanded men in this county, aside from the rice interest, nothing has been done with the salt-marsh lands, notwithstanding they can be purchased and reclaimed much cheaper than the rice lands. No one questions their productiveness, and eventually many will be reclaimed, and made nearly as valuable as the rice lands.

Replies to Queries.—The *salt* marsh is generally of decomposed vegetation with alluvial deposit, and at a depth of 3 feet blue clay is often found, mixed with an equal quantity of sand.

The *fresh* marsh or river swamp is vegetable matter with a larger amount of alluvial deposit, more like mud or yellow clay.

The cost of constructing dikes per square yard is about 15 cents.

The cost of diking and draining per acre varies according to locality, and amount reclaimed in one body. In some instances 10 acres could be diked for $10 per acre, and a larger amount, say 100 acres, for $4 per acre. This would be salt or brackish marsh. The fresh or river swamp would cost $40 to $50, or more, per acre to prepare it for planting rice.

The salt marshes have to remain a year after diking in order to get the salt out of them by the rains, unless the water is but slightly brackish. The fresh marshes can be planted at once after diking and clearing. Some of the rice lands have been planted over fifty years—kept fertile by the sediment from the water used to flow the rice.

Such lands are never used for pastures or meadows, and very little for general farming, rice being made a specialty. Other crops do well under "dry culture" on the rice lands. They produce rice, cotton, corn, vegetables, &c., *much* better than uplands, and require no fertilizing. Disadvantages—expense of keeping the banks and gates in repair, and danger from extraordinary freshets in the upper portion of a tidal river, or extra storm tides near its mouth. But these risks are small compared with the greater production of tide lands.

Marshes must border a stream having an average tidal rise and fall of 4 feet to insure good drainage in case of heavy storms.

In this county (Camden) it is claimed that from fifteen to twenty thousand acres of salt and brackish marsh, and five to six thousand acres of fresh or swamp tidal land might be reclaimed with profit.

Lands that are flowed, as is done in raising rice, are unhealthy, but the uplands are not affected.

Unreclaimed rice lands are worth $10 to $15 per acre; uplands adjoining, $2 to $4 per acre; reclaimed rice lands, $50 to $80 per acre; salt or brackish marsh, unreclaimed, in favorable localities, $2 to $4 per acre; when reclaimed, $50 per acre.

Any tide lands that can be reclaimed at a reasonable expense yield better returns on the capital invested than uplands.

FLORIDA.

[J. G. Knapp, State Statistical Agent for the Department of Agriculture.]

There are no laws in the State of Florida relating to the reclamation of tidal or swamp lands, except the charter under which the drainage of Okechobee Lake and the Everglades has been undertaken by the Disston Company.

Those rivers in Florida which form the boundaries of riparian owners are not subject to great overflows, changes of channel, or deposits on their banks, and controversies about ownership will not be likely to arise therefrom. There is very little wash into the streams from the banks of any of the rivers, and consequently little deposit of mud—none below tide water. All the rivers have their origin in the rainfall, and not from mountain streams. They are low in the dry seasons, and

grass, weeds, and bushes spring up and effectually prevent all eroding of their beds or sides.

It is too late to question the Congressional legislation that gave the swamp and overflowed lands in Arkansas to that State for the purpose of draining and protecting them from overflow, and the extension of the same laws to all other States in which were public lands. The title to these lands has passed from the General Government to the several States, and in few, if any instances, have the objects of the grant been carried out by the States. Under that legislation, Florida came into possession of a moiety of all the lands within her limits. The presumption was that laws would be passed calculated to carry out the objects of the grant, but facts do not sustain that presumption. Had these lands been properly and systematically drained, they would have given to Florida more rice and sugar lands than to any other two States in the Union, and added largely to the yield of corn and other cereals. But the Legislature of the State seems to have entirely forgotten the object of the grant and sold these lands to individuals, without any conditions, at prices ranging from 25 cents to $1 per acre.

The marshes of Florida consist of tidal and river marshes, and what might be designated as the lacustral system of swamps. The tidal marshes may be redeemed, flooded from the fresh-water streams, and converted into good rice grounds.

The fluviatic marshes lie on the margins of all the large streams, and with each rise of the river they are submerged. Such lands if reclaimed would be very rich and produce almost all kinds of crops, and be valuable as market gardens.

In the lacustral swamps, the water is retained by long ridges, where it gathers in shallow beds during the rainy season. Some of these are covered with cypresses, bays, cabbage palmettos, and other trees that delight in water. Some are meadows, where coarse grasses, rushes, and weeds, with gall and other bushes grow, and there are many open, shallow lakes. The natural drains are insufficient to carry off these waters, though at times the swamps become dry by evaporation. Their beds are generally covered with rich vegetable matter, and nearly all would become good rice and sugar lands if the water were controlled.

The center of the peninsula, as far south as twenty-seventh parallel, has an altitude of from 100 to 250 feet; yet these lacustral marshes are found on its sides and even on its summit. One instance will suffice; in the counties of Hernando, Polk, and Hillsboro, at an altitude of over 100 feet, lies a tract of lacustral swamp, containing fully 400 square miles, in which the Oklawaha that debouches into the Saint Johns, the Withlacoochee, into the Gulf at Cedar Keys, the Hillsboro into Tampa Bay, Peace River into Charlotte Harbor, and the Kissimme into Okechobee Lake, take their rise. This tract is composed of small cypress swamps, wet meadows, gall berry and scrub palmetto swells, all at times submerged by rains, and a complete net work of drains to the rivers through which they discharge. Few roads traverse it, and nobody can reside on it. It is a barrier, over which few travel, and no railroads have been built, yet all could be drained and converted into rice and grass fields. Purchasers avoid it, and though the railroads claim it as part of their grants, no steps are taken to redeem it from the waters that cover it in the wet seasons, or the fires that devastate during the dry. In the wet seasons, the traveler can find no camping ground, and in the dry no water.

Similar tracts, of various sizes, are scattered from the northern limits of the State to the boundaries of the Everglades. These are unmapped, undescribed, uninhabited, yet all may be made productive and healthful.

NASSAU COUNTY.

[James T. O'Neill.]

An effort was made near Fernandina to reclaim tidal lands far a dairy farm, but abandoned. There is a plenty of brackish tidal marsh lands in Florida, north of Saint Augustine on the Saint John's and Nassau Rivers, that are susceptible of reclamation and would be adapted to the culture of cotton and vegetables. Such lands in the southern and eastern part of Georgia were reclaimed and successfully cultivated before the war, but have been abandoned. It would be folly, in the present status of labor, to attempt the reclamation of such lands.

Rivers vary in the character of their water; some are clear, others muddy. The former are not so good for rice as turbid streams, which leave sediment from flowing. On the coast lands of Georgia and South Carolina before the war, salt tidal lands, or rather the mud and grass from them, were used as manures for contiguous high lands which were much improved thereby. The mud and grass after being hauled out were left to rot and sweeten, before being used.

[Charles W. Lewis, Chairman Board County Commissioners.]

About 20,000 acres are subject to tidal overflow from the Atlantic. This land is generally not assessed or valued for taxes, being mostly unsurveyed. The small area taxed is valued at about 25 cents per acre. Marsh lands are regarded here as of little value, say 50 cents per acre.

Prior to 1860, about 400 acres were diked and drained for rice on Saint Mary's River, but the dikes have been almost entirely destroyed and the marsh is again subject to overflow. Two hundred acres were also diked and drained for other farming; about half of this is now cultivated for early vegetables. The assessed valuation of the last-mentioned tract (100 acres) is about $8 per acre. I presume the cash value is at least $25 dollars, and for some parts of it $50 per acre.

The obstacles to reclamation are cost and (possibly) want of knowledge of approved methods. I think however the chief reason why the marshes are not improved is that there is in Florida a very large area of uncultivated land for sale (as well as public lands for entry), much of which is regarded as equal to if not better than the marshes, and which can be put under cultivation at less expense.

DUVAL COUNTY.

[J. G. Perkins.]

Near the mouth of Saint John's River, marsh lands consist very largely of islands in the river which are extending very rapidly. It is said that the entire river marsh is a growth of the last fifty years.

CLAY COUNTY.

[Thomas Roberts.]

There are no known obstacles to reclamation, but it is not likely to be attempted until the area of unimproved upland becomes smaller. The numerous water-courses of this region are bordered by extensive

tracts of heavily-timbered swamp lands, which are generally subject to tidal overflow. The soil is alluvial and of considerable depth. The cost of clearing has, thus far, prevented their utilization.

PUTNAM COUNTY.

[J. T. Tenney.]

The marshes are covered with cypress, ash, gum, bay, elm, and maple, the cypress being used for lumber. The value of such lands is small.

On Deep Creek, in Saint John's County, are thousands of acres of marsh land, covered with dense forest.

These lands are all susceptible of reclamation. The muck taken from them is found to be a valuable fertilizer, and is used to a considerable extent in this section. This marsh is subject to overflow by tide water.

VOLUSIA COUNTY.

[D. D. Rogers, C. E.]

Nearly all the tide marsh is United States unsurveyed land, and as the laws governing surveys were made for the Western States, it is impossible to get these lands surveyed. The first requirement is that the applicant shall reside on the land, and a salt marsh is not a very pleasant spot to live on, though not unhealthy, as many people suppose; hence the work of reclaiming tide marshes in Florida is not pushed forward.

DADE COUNTY.

[Richard B. Potter, M. D.]

Twenty thousand acres along the coast of this county are more or less subject to tidal overflow. The rise of ordinary tides is about 2 feet, of storm tides from 3 to 6 feet. The average elevation of the marshes above low water is 3 feet. Soil generally muck or clay, no sand, some peat. Vegetation not utilized. Marsh land is generally owned by the State. No diking has ever been attempted.

[W. H. Gleason.]

The tide marshes of Key Biscayne Bay, Card's Sound, and Barnes' Sound are fringed with mangrove from 15 to 40 feet high, which, when the lands are improved, will make an excellent wind-break; the growth is very dense and almost impassable. From the head of Key Biscayne Bay to the north line of the county, the ocean beach is a high sand ridge, with only a few breaks formed by the streams flowing into the ocean. These streams are fringed by strips of salt marsh from 20 to 100 rods wide. The tides northward from Cape Florida rise higher than in Key Biscayne Bay, Card's Sound, or Barnes' Sound. The tide at Jupiter Inlet and Lake Worth is about 5 feet. There is very little salt marsh in this part of Dade County.

MONROE COUNTY.

[Dr. J. V. Harris.]

There is no doubt but these marsh lands can be reclaimed much cheaper than ordinary lands can be cleared. There is generally a narrow ridge of land on the banks of the rivers and inlets. By cutting

ditches through this bank, and through the mangrove swamps, to the marshes (or prairies, as we call them), we can get an outlet for the water. It is necessary, however, to dike the marshes to prevent the flow of water from adjoining lands. The general depth of the soil on the marshes is 3 feet. When it is thrown up in heaps, it crumbles in a few days, and presents the appearance of well-rotted stable manure. Underneath the vegetable matter is a black, glistening, oily mud, which, when dry or slightly burnt, takes a fine polish, resembling black marble.

These lands, if reclaimed, would be invaluable for early market gardens, for bananas, plantains, melons, sugar-cane, and rice.

HILLSBOROUGH COUNTY.

[J. M. Craner.]

There is a large amount of saw grass land, just above high water, that can be drained by means of flood-gates and ditches. Some, having been drained and cultivated the past year, proved very profitable.

HERNANDO COUNTY.

[John Paisons.]

I know no tide marsh reclaimed, if I may except a little adjoining my garden. The marsh lands could be made very valuable for raising vegetables, but at present only lands for orange culture are sought.

WAKULLA COUNTY.

[J. M. Adams, jr.]

Six thousand five hundred acres of tide marsh around this place (Saint Mark's)—about 25,000 acres within 20 miles; general elevation above low water, from 3 to 5 feet. Spring tides rise 4 feet; storm tides, 15 feet.

Value of cedar marsh, 50 and 56 cents; other marsh 5 or 10 cents; where there are fisheries, for a few acres, perhaps $100 to $1,000 per acre. Cattle keep fat on the marshes all winter, but sicken in summer from the effect of some kind of grass and salt water. The marsh lands extend from the Gulf back about 3 or 5 miles. The adjoining lands are very good for corn, cotton, or sweet potatoes.

FRANKLIN COUNTY.

[J. C. Brayton.]

The tide lands of this county are all wild, and no effort has been made to reclaim them. The owners of some two-thirds of them are residents of other States. They are assessed at about 10 cents per acre. Along the coast, and within 3 to 9 miles above the mouths of the rivers, the marshes are open, covered chiefly with rushes and saw grass. Farther up, especially along the Apalachicola, its delta and branches, are large areas partially flowed at high tides, and wholly so by freshets in the rivers. These lands are as rich as the Mississippi bottoms near New Orleans.

Tidal waves occurring at the autumnal equinox, or near that time,

once in four to six years, raise the water of the bay 5 to 6 feet, and at longer intervals 9 to 11 feet above mean low water. To resist these high waves would involve an expense which the owners have not felt warranted in incurring.

About 50,000 acres are in the delta and valley of the Apalachicola River and its branches, within 20 miles of the coast. In the eastern part of the county, mainly along the valley of Carrabelle, Crooked, and Ochlockonee Rivers, are 40,000 acres; in all, 90,000 acres (marsh land) in the county.

[E. Smith.]

No reason why marshes here could not be reclaimed. These lands are as rich in vegetable matter as any in the world, and if once reclaimed would produce corn, cotton, sugar-cane, &c. The same kind of land along river higher up produces a bale of cotton to the acre; but, owing to risk of overflow, very little is cultivated; no dikes or dams are used.

WASHINGTON COUNTY.

[C. H. Colquhoun.]

No use whatever is made of the marsh lands in this neighborhood, (Saint Andrew's Bay, including East Bay, West Bay, and North Bay). The salt marshes are on the bays, and the fresh and brackish marshes at the mouths of Econfina, Bear, and Cedar Creeks. Upon the latter a very luxuriant tropical growth is found. The palmetto is here in abundance. The salt marshes were used by salt-makers before and during the war, by sinking shallow wells and boiling.

SANTA ROSA COUNTY.

[Hon. John Chain.]

About 25,000 acres of tide marsh on the Escambia River and Pensacola Bay, and 18,000 acres on Black and Yellow Water Rivers. Ordinary tides, 2 feet; storm tides, from 4 to 6 feet; elevation of marshes above low water, near 3 feet. The soils are various; those of the Escambia River are silt from a cultivated loam. Very little peat, except in swamps fed by springs. These swamps have, generally, a white sand foundation. The islands, at the mouths of the rivers, are composed of 14 per cent. organic matter, 8 per cent. alumina, 4 per cent. lime, potash and soda (chloride), and the remainder very fine sand. The lands higher up the rivers contain more organic matter—perhaps twice as much. The principal vegetation on the bay lands is the round, sharp-pointed rush. Near the mouths of the rivers it is coarse marsh grass and the common reed. Up the rivers the growth is cane and heavy swamp timber.

Much of this land belongs to Spanish grants, and the rest is State land. The value is nominal, capital never having been directed in that line. None diked, though some has been cultivated in rice, without diking, and made over one hundred bushels to the acre with no other preparation than cutting down the cane and burning it, cutting a trench with an ax, planting the rice and hoeing it twice. A full crop came up the next year, of volunteer rice, which the hogs were allowed to destroy. I experimented on these lands with many vegetables, and,

when properly cared for, all did well. One acre was nearly diked, at a cost of 10 cents per running yard—$5 more would have finished it, when it would have rented for $50 a year—but other business was more attractive and it was neglected. The Walton County lands are a medium between the yellow and Escambia River lands. The amount is about the same as in this county (Santa Rosa).

ESCAMBIA COUNTY.

[J. W. Crary, County Commissioner.]

Our salt marshes are alluvial deposits from the rivers which flow mainly from Alabama, with crustaceous and other marine matter. Where the marshes are above common tide, a large part of the soil is vegetable. Our marshes are overflowed by high tides, but are generally 2 to 4 feet above common tide, except near the seaward edges. The tide at Pensacola during heavy storms rises about 6 feet; mean tide, about 3 feet.

I do not know of any experiments in reclaiming marsh land here that would justify a positive statement as to practicability of excluding transpiration water. All of our marsh lands, if reclaimed, would be valuable for the culture of rice. In fact, rice will grow anywhere in our ponds or lowlands, but a periodical flooding would be profitable. The whole of this section is underlaid with clay.

ALABAMA.

BALDWIN COUNTY.

[G. W. Robinson.]

About 100,000 acres of tide marshes in this county; general elevation of the marshes above low water, 2 to 2½ feet; common rise of the tides, 1½ to 2 feet; storm tides rise 5 or 6 feet, but are very rare. Marshes generally owned in large tracts. Soil peaty. Value, 25 cents to $1.25 per acre.

Gardeners dig two parallel ditches 10 or 12 feet apart and make a bed producing the finest of vegetables without fertilizing. There have been no attempts to inclose. Railroad companies own most of the marsh.

MOBILE COUNTY.

[W. H. Gardner.]

The marshes in Mobile County are mainly salt marshes, all the upper part of the bay ending in them.

Ordinary tides, 18 inches at lower opening of the bay, 2 or 3 feet in the vicinity of the city; storm tides, 2 feet 6 inches at mouth of bay, 8 to 10 feet above extreme low tide at city. Elevation of marshes, 1½ to 3 feet above low tide. Soil very fine alluvium. No sand or peat. Not utilized. Cows graze on some portions. Hogs devour craw-fish and eat grass roots, but not to any profitable extent.

Lands owned almost entirely by individuals; very little by the United States or Alabama. Some portions east of the city have been reclaimed, and produce garden vegetables abundantly; but the area so reclaimed is very small and only on more elevated portions. Sales have recently

been made of small bodies near the city, at full prices, but only of eligible lots for handling of pine lumber and stores. Otherwise the value is merely nominal.

During the equinoctial gales—generally from August 20 to September 15—these marshes are all under water, and have been badly overflowed as late as October 11; rarely so from February to August, the period which includes the vegetable season. Near the Gulf, a portion of the marsh front is used for raising the "diamond back terrapin," which finds ready sale, at high prices, in Baltimore, Philadelphia, and New York. A large extent of the marsh could be so utilized, and with more resulting profit than a poultry yard of the same area.

[Hon. John R. Tompkins.]

The swamp and overflowed lands donated by act of Congress to the State of Alabama were almost entirely located in a few counties bordering the Gulf of Mexico. These lands embrace some river swamp on the Lower Alabama (or Mobile) River, and isolated marshes and savannahs on and near the coast or on creeks and rivers some distance in the pine forests, where they were alone valuable for timber, having no agricultural value whatever. With no State agent to supervise them, they were for many years subject to depredation for the little timber that grew on them. They aggregated some 400,000 acres. The State authorities, seeing the interest of the State alone in selling and transferring them to the tax books, ordered them sold, and, with the exception of some 60,000 to 80,000 acres, the entire lands were sold, ten or twelve years ago, at prices ranging from 10 cents to $2.50 per acre, according to the schedule of prices fixed by commissioners, and the proceeds, less expenses of the sale, paid into the State treasury. None of these lands are considered to have any value whatever for agricultural purposes, nor would their redemption by ditching, drainage, &c., as contemplated by the act of Congress making the grant designed to apply to the alluvial bottoms of the Arkansas, White, and Mississippi Rivers, be of any material advantage in enhancing the value of adjacent public lands.

Cypress timber gave these lands in Alabama their greatest element of value. Some lands on the coast adjacent to them, near the Mobile and New Orleans Railroad, in the lowest portion of Mobile County, have been successfully adapted to the cultivation of rice. Where the soil is possessed of any fertility rice is successfully cultivated, in this county, on lands near the coast not classed under the head of swamp and overflowed lands.

MISSISSIPPI.

HANCOCK COUNTY.

[Howard W. Wilkinson.]

Twenty-five thousand acres of tide marsh in this county. None has been diked or drained. It appears to be vegetable matter, from 10 to 20 feet to clay. If drained it would produce rice, melons, and vegetables better than other land; that is our experience with small patches. The northeast and southeast gales drive the tides over the marshes to a depth of 7 feet, and being spongy they won't bear the weight of a levee sufficient to keep the tides out.

The assessed valuation of these marshes is 50 cents per acre, but the market value is about 15 cents.

A grass grows on them that in the early spring is very succulent and rich, sought after by and fattens cattle better than any of our cultivated grasses, but it grows to immense size, and becomes tough and useless after six weeks old. The tania grows to perfection, and produces a root which when boiled and mashed can't be distinguished from the Irish potato. It is from 6 to 10 inches in diameter, and may in time take the place of the present grasses.

LOUISIANA.

[William H. Harris, State statistical agent for the Department of Agriculture.]

The tide lands of Louisiana extend the length of the coast, from Pearl River to the Sabine, with a width of from 10 to 30 miles. They are dotted with lakes and intersected with sluggish bayous. The character of the land is not uniform. In some places it is covered with water a few inches deep, and very boggy; at others sufficiently firm to support the weight of cattle. There are found also in this tide-land section the "trembling prairie" (with a firm crust of roots and fibers floating above water and mud), islands, cheniers, and buck ridges of firm black soil, very rich, and covered with a natural growth of live oaks and groves of oranges, some of them planted nearly a hundred years ago. The soil along the bayous is alluvial and cultivated in rice, sugar, oranges, Japan plums, figs, bananas, and some guavas. On the lakes and bayons are numerous "Indian temples," or shell mounds. The soil of the sea marsh proper is, for a depth of 18 inches, a black mass of decayed vegetable matter, covered with a heavy growth of grass, and capable after drainage of growing *at once* any of the products of Louisiana. The subsoil is a stiff blue clay, admirably adapted to the building of dikes. These lands are generally owned by the State of Louisiana, and are sold for 12½ cents per acre.

The planters living along the bayon banks, which are highest next to the streams, pasture their cattle upon the tide lands winter and summer. The hunters and fishermen living on the islands and cheniers also graze their cattle on them (only a few), and hunt deer, rabbits, and ducks, and "bed" oysters in the bayous for the New Orleans market. The hog has a holiday the year round in this region.

In 1878 the Louisiana Land Reclamation Company was organized in New Orleans, under a charter from the legislature, and by a system of canals, levees, and dikes, built by steam dredges, 13,000 acres were reclaimed in the tidal region of Terre Bonne Parish. The land was broken up by steam plows, plying between parallel canals, and operated by the engines of two steam-dredging machines, floating in the canals at opposite sides of the fields. Rice, jute, and vegetables have been cultivated on this reclaimed land successfully. The company claims a larger yield of rice than the South Carolina lands give under the most favorable circumstances. Jute grew 6 feet in five weeks on this land.

The company has recently lost several of its largest stockholders by death, and in consequence operations in reclaiming an additional body of land have been retarded, but will shortly be resumed.

The elevation of these lands at low tide is 18 inches. They are barely covered by high tide.

ORLEANS PARISH.

[Alexander W. Weems.]

The tide marsh in this parish is about 40 miles in length, and from 3 to 15 in width; elevation above low water from 1 to 3 feet; common rise of the tides about 15 inches, when not influenced by winds; storm tides rise from 2 to 6 feet. The marshes, which are owned almost exclusively by the State, are principally alluvial, and produce a very heavy growth of a species of red top, and a long-bladed no-stem grass, unsurpassed for grazing all stock, excepting sheep. The State sells such lands at 12½ cents per acre. Pine lands range from Government price to $5 unimproved.

This is not an agricultural district—timber, wood, and brick being our staples. In 1846–'47, 250 acres between Lake Ponchartrain and Pearl River were inclosed by a 5-foot dike, and sea island cotton planted. After being brought to good tilth, the yield was unequaled and the staple unsurpassed.

In 1858 I raised on diked land 100 bags of cotton, averaging 250 pounds—the work of 13 hands, two of them quite old—and continued with like success until stopped by the war. I have not planted since, my buildings and fences having been destroyed and labor being scarce and unreliable. I am now engaged in stock-raising. My levees are in as good condition as when first built.

TANGIPAHOA PARISH.

[Robert Lynne.]

There is an area of about 5 by 10 miles of tide marsh in this parish. Ordinary tides rise 1 foot, storm tides 5 or 6 feet. The marshes proper are never absolutely free from water. The soil is mostly sand or silt; the decaying vegetation undergoes an offensive decomposition, but never assumes the condition of peat. The marshes are not utilized. They are held mainly by private owners, but have no recognized value.

[George H. Biegel.]

These marshes could be easily reclaimed by levees, and would be invaluable for rice or cabbage. The Illinois Central Railroad runs through them. A 4-foot levee would be necessary. A tract has been reclaimed and cultivated in rice very successfully by J. A. Cooper.

SAINT BERNARD AND PLAQUEMINE PARISHES.

[Lewis J. Johnston.]

The marshes covering a large part of these two parishes are not used for pasturage, as they are not firm enough to support the weight of animals, and the mosquitoes are bad in the summer. The land is nearly all owned by the State, and has a nominal value of 12½ cents per acre. Very little land has been reclaimed by diking, as there is much in both parishes, above tidal overflow, that is yet uncultivated. Where this marsh land has been drained, it is very productive.

TERRE BONNE PARISH.

[Jas. D. Wilson.]

In this district the tide marsh is about 100 acres to 1 acre of high land. The general elevation above low water is 6 to 8 inches, the common rise of the tide 12 to 14 inches; storm tides rise 2 feet higher. The vegetation is sea marsh grass, and is not used. The marshes have no value. Adjoining upland is worth $100 per acre. No marshes are diked.

SAINT MARY'S AND IBERIA PARISHES.

[G. W. Thomas.]

All the southern portions of Saint Mary's and Iberia parishes, bordering on the Gulf and its inlets, are subject to overflows of tide water (some salt—some fresh) for a distance inland of some 15 miles, and storm tides go much further inland. These lands are called sea marsh, though a large portion is cypress swamp and low prairie, yet all affected at times by high tides. Along this northern shore of the Gulf of Mexico, the ebb and flow is controlled by winds. Some portions of the year there is scarcely any rise or fall for weeks at a time.

The prairie portion is composed of sand and clay; the higher marsh land has but little if any sand and is generally red and blue clay with a thin soil of decomposed vegetable matter. The low marshes were once shallow lakes and owe their present elevation to the accumulation of vegetable matter—the muck being 20 feet deep. Outside of this low marsh, immediately on the bank of the Gulf, there is an elevation of some 3 or 4 feet, composed of marine shells and washings from the Gulf, on which grows the Mexican mesquit and other shrubbery. The base of these elevations is same as the bottom of the Gulf, which here is a stiff, tenacious blue clay. I think this portion of Louisiana was formed from erosions of the Red River, and not by the Mississippi. The Mississippi, in forming its delta, first deposits sand just outside of its main current, and in rear of this clay, or black and blue mud. The Red formed what is called here the Attakapas region, first depositing sand, then sand and red clay (which is lacking in the Mississippi deposit), and then the lighter blue and black clay, with but little sand, which is the formation of the low prairies and part of the higher marshes. My belief is that the present low sea marsh does not owe its origin to any silt depositing river, but is simply an accumulation of vegetable matter.

These low prairies and marshes are considered by the stockmen common property, and their herds range over areas of 30, 40, or 50 miles in summer, on high marshes and low prairies, and in the winter down in the lower marshes, immediately on the Gulf coast. Circumstances are driving the larger herds of cattle west of the Sabine into Texas, and the stock business bears no comparison with what it was some years ago. But a small portion of the marsh is owned by the people who use it.

The State has lately made a very large sale of these lands in Cameron parish to an English syndicate, at the price of 12½ cents per acre. All tidal and swamp lands are subject to entry at that price. These lands may be put under cultivation, if undertaken in the proper way, and they will be the most productive in the Union.

[W. J. Thompson.]

The tidal marshes of Saint Mary's parish are very extensive. Those readily and profitably to be reclaimed by dikes may be divided into four districts, viz: (1) East of Atchafalaya River, owned and reclaimed part by Louisiana Land Reclamation Company; (2) West bank of Bayou Teche from Atchafalaya River to Bayou Salé; *i. e.*, from Berwick (opposite Morgan City) to Centreville, including a portion of township 16 S., R. 12 E., about 2,500 acres, of which 500 are already surrounded by plantation levees, and cultivated in cane, corn, and in one instance, rice; (3) Ditto, from Bayou Salé to Bayou Cypremort, or just beyond, *i. e.*, from Centreville to parish line, about 2,400 acres, of which probably not 300 are reclaimed; (4) Bayou Salé—both banks and Bayou Cypremort—east bank especially—about 1,600 acres, of which say 200 are behind levees and cultivated. All lands in the first district are open marshes, covered in normal condition by rank wild grasses; those of the second, third, and fourth districts are comprised in a narrow strip of heavily timbered swamp land, lying between the higher lands along the bayous named—already long since improved—and the great expanse of open sea marsh proper. Portions of latter three districts denominated *reclaimed*, are mostly diked only against storm tides, and are not affected by diurnal tides. The exact extent even of these is unknown. The water overflowing all lands practicable to reclaim is fresh, namely, swamp and bayou waters backed up by Gulf tides. Little is known, except by hunters, of that far greater portion of tide lands—open, peaty marshes—which extend from this strip of woodland to the sea. The woodland strip is from one-fourth to 3 miles wide, but only its inner edge is to be readily reclaimed, owing to difficulties and expense of clearing and draining. In the outer, open marsh several "islands" rise, 40 feet it is said, above mean tide. Cow Island and Côte Blanch, in Saint Mary, and Grand Côte and Petite Anse, in Iberia parish, are examples of these. Some are already the sites of sugar plantations.

The general elevation of the marshes is from the level of low water to 24 inches above, in general, say 12 inches. Those now reclaimed from the wooded belt probably 18 to 30 inches. The open marshes diked by the Louisiana Land Reclamation Company are not so high. As stated, very little is known of the great open-sea marshes except by hunters.

Highest observed storm tide at Calumet Plantation 48 inches. This plantation is 13 miles from Morgan City or Berwick, 7 from Centerville, and the same from open salt water, with which its swamp is connected by a net work of small, partially obstructed bayous.

Wooded belt owned in large tracts, attaching to neighboring plantations by old Spanish grants. Open marshes partly owned by Louisiana Land Reclamation Company, and balance by State of Louisiana, under title from the United States. Wooded belt alluvial—balance peaty. The alluvial portions are such for an unknown depth—clays partially of Red River origin. The surface differs from lower strata by addition of vegetable mold, roots, &c., generally from 2 to 8 feet deep, and varying in character with flora, and flora with it. The so-called islands, amidst peaty portions, have general character of higher lands of the section, except in parts they are more elevated than any of these. Vegetation on wooded strip next to higher lands, cypress, live oak, ash, maples, varieties of palmetto, &c., used for fire-wood on plantations to some extent—for lumber rarely. Beyond this strip the open marshes are covered with coarse, wild, and very heavy grasses, vetch and other vines, &c., put to

no service. Vegetation varies with a few inches difference in elevation above mean tide.

Value of open-sea marsh, nominal. Wooded belt next to higher lands assessed at $3 and $4 per acre. These higher, cultivated lands assessed at from $20 to $30 per acre. Recent sales at $33 in large tracts (six hundred acres).

Reclamation undertaken on a large scale by Louisiana Land Reclamation Company. Its operations in Saint Mary's parish confined to portion east of Atchafalaya River. West of Atchafalaya, from Berwick to Franklin, small tracts immediately adjoining and forming part of plantation have been diked, the rain-water being lifted by appropriate draining machinery (usually a [Elba] drainage wheel). D. Thompson Bartels has 100 acres so reclaimed, and proposes to add shortly 100 more. L. S. Clarke and D. Thompson, severally, propose to drain higher lands through automatic flood-gates. Heretofore water has been pumped out.

No failures known from an engineering aspect. As levees need to be be but 2 to 3 feet high, no excuse could be found for such. These levees have heretofore been improperly constructed, it is true, and will, in many cases, require rebuilding in a few years, being unprotected from cray-fish, muskrats, &c., but the expense of building is not excessive. Poor returns upon investments have been occasionally made no doubt, owing to several causes: (1) difficulty and great expense of clearing the wooded portions above mentioned; (2) difficulty and expense of cultivating during a number of years—(planted in cane not less than $30 the first year and $25, second and third years, per acre—probably more); (3) soil too rich in soda, potassa, and ammonia salts to produce canes of high saccharine strength for several (say, eight) years; (4) expense of pumping rain water—the fall from higher to lower levels being so slight that, in the past, it has been considered necessary to pump all drainage; (5) neglect to pump canals empty at proper times; (6) insufficiency of ditches and inadequaet reservoir capacity of canals—heavy rains filling these and flooding low lands before drainage machinery was put in operation; (7) leaky or low dikes, causing unnecessary and expensive pumping.

Informant, with legal residence in New York City. is acquainted with such work in New Jersey. Attention in this section is given to the far more serious problem of protection against inundation from the Mississippi River. Private levees for this purpose, 30 feet at base, 6 or 7 feet across crown, and 8 or 9 feet high, not uncommon, as defense against crevasse water escaping through breaks in the greater Mississippi River embankments. At present (May 4, 1884) 6 feet of water covers fields for a distance of 35 miles or more on the Atchafalaya River, having declined 2 feet. These lands lie on the Grand Lake basin, a portion of the Atchafalaya's bottom, and are not subject, ordinarily, to tidal overflow. There are no engineering obstacles to the reclamation of wooded strip immediately adjoining higher lands already described, as against tides. Even these lands, however, whether enumerated as reclaimed or not, so far as Saint Mary's Parish is concerned, excepting only Bayou Salé and Cypremort districts, are liable to river overflow. The flood wave of 1883, from the Mississippi River, rising about 11½ feet above level of lowest cultivated lands on the east bank of Bayou Teche, poured into this bayou and over its high west bank, through much of its extent, covering cultivated lands as much as 9 feet in the lowest portions.

The above, so far as numerical answers are concerned, must be considered as the merest approximation only to correctness. Many circumstances combine to render this subject little thought of in this section;

while the topography of the country is such, and complications are so numerous, as to make any attempt at concise statement exceedingly liable to error and particular affirmations equally liable to contradiction, when applied to special localities or cases. Observations of a careful and systematic sort are entirely lacking west of Atchafalaya River and averages therefore are impossible as to elevation and extent of lands, height of tides, and the like.

TIDE MARSH LANDS IN SOUTHWEST LOUISIANA.

[J. B. Watkins.]

The large body of sea-marsh land in Southwest Louisiana, extending along the coast from Sabine Lake eastward to Vermillion Bay, a distance of 120 miles, and inland for from 15 to 30 miles, has been almost unknown in the past. From this entire tract of land the waters of the Gulf have gradually receded. The sediment from overflows and the decay of the very large, dense vegetable growth have gradually raised this land until it is now above the natural level of the Gulf, and the soil thus formed is not surpassed for fertility by any land in the world, being a very black vegetable mold, from 1 to 6 feet in depth. The subsoil is a tough, waxy blue clay, well adapted to prevent any leakage. Within this extensive level tract, and east of it, surrounded by similar marsh, are rather abrupt elevations of land, from 8 to 60 feet higher than the surrounding country. These were once islands in the sea, and are still called islands—the higher ones, mountains. These have for many years been inhabited, and contain now the larger portion of the settlers of this region of country. These islands are very fertile, and particularly adapted to the growth of oranges, figs, and other tropical fruits.

Sabine Lake and River are navigable for 300 miles from the western boundary. Thirty miles east of the Sabine are the Calcasieu Lake and River, flowing in the same general course, navigable for 100 miles from the Gulf. Thirty miles still further east are the Mermentau Lake and River, navigable for 60 miles. Forty miles east again is the Vermillion River, flowing in the same direction. These rivers all have their source south of the Red River watershed, which extends from Northern Texas, in a southeast direction, to the Gulf, at a point west of the Mississippi delta, 100 miles from New Orleans. This region is thus absolutely protected from the floods of the Mississippi River and its tributaries. The four rivers named, which pass through this region, having their sources in and courses through a flat country, have a gradual and moderate rise and fall on account of rain storms.

The four principal lakes in this region—Sabine, Calcasieu, Mermentau, and White—are nearly equidistant from each other and nearly on a line with the Gulf coast, and are also of nearly equal area, the four embracing about 360 square miles. There are numerous other smaller lakes within the borders of this tract of land. White Lake is so named on account of the appearance of the bottom, which consists entirely of sea shells. The bottom, together with the numerous fish which abound, can be distinctly seen through the very clear water.

At some places along the course of the streams and around the lakes, and especially along a considerable portion of the Gulf coast there is a natural levee. This levee along the coast extends eastward from Sabine Lake a distance of 70 miles. It is from a quarter of a mile to 2 miles wide, and of sufficient height to resist successfully the highest storm tides, except at two places for a few miles each. These are at and adjacent to the mouth of the Calcasieu and Mermentau Rivers.

This tract of land is the base of a triangularly-shaped region of prai-

rie and prairie marsh, with dense forests on both sides, to the northeast and the northwest, the apex being 50 miles north of the Gulf coast and the open base 120 miles along the Gulf coast. To this natural feature of the country, affecting as it does the sea breezes so favorably, is to be attributed the peculiarly delightful and healthful climate of that locality. The thermometer (Fahrenheit) during the last six years has ranged from 27° in the coldest day in the winter, to 94° the warmest in the summer.

In such a climate and with such a soil the most abundant growth of vegetation is found. In the swamp land the grass remains green the entire year, and because of this and the very mild climate it is an excellent grazing country. In its present natural condition thousands of cattle roam at will without any attention being bestowed upon them.

When I saw this country and studied its natural features I decided that capital could be profitably invested in its reclamation and preparation for successful settlement and cultivation. I therefore purchased from the State and United States Governments all of the vacant lands within limits that I fixed, extending to 30 miles inland.

Our plan of reclamation is to build dikes along the gulf, rivers, lakes, and bayous, of sufficient height and strength to prevent overflow of each in the event of floods from rains and storm tides; and in this we will be materially assisted by the natural levees found in many places along these waters. We cut, parallel to each other and half a mile apart, canals 18 feet wide and 6 feet deep. At right angles with these, at intervals of 2½ miles, we cut larger canals, thus forming the land into oblong blocks half a mile by 2½ miles, each containing 800 acres. Across these blocks, at proper intervals, we cut lateral ditches 30 inches deep by 8 inches wide at the bottom, flared to 30 inches wide at the top.

The canals are cut, the levees formed, and the dikes are to a considerable extent built by the use of powerful floating steam dredges. The excavated dirt is deposited on both sides and forms levees about 3 feet high. The canals are used for the combined purposes of drainage, irrigation, and local transportation. The smaller ditches are cut by ditchers propelled by steam power, passing through but once at the rate of 1½ miles per hour.

At proper localities we erect automatic flood-gates, by means of which we control the stage of water in the canals, and the necessary volume of water is regulated to some extent by the ebb and flow of the tide. This is supplemented by the use of powerful wind pumps, and, when the natural elements will not accomplish the work, we readily move upon the canals to the spot our ditching, plowing, and cultivating engines and attach them to the pumps. Thus arranged, with control of the water, these blocks of land are in condition for the most successful rice culture.

Rice may be planted any time from February to June, very much the same as wheat and upon ground similarly prepared. When it has reached a growth of 2 inches high, water is let in upon it and the ground gradually flooded, care being had not to cover any of the plants with the water. The land is kept flooded, sufficiently to kill all the grass and weeds, until the rice is about 18 inches high, it then has sufficient start to choke down any foreign growth, and the water may be drawn off and the ground allowed to become dry and firm for harvest time, which may extend over several months, according to the times the seed was sown. Rice is harvested and threshed in the same manner and with about the same kind of machinery as used for wheat.

Our operations were begun in December, 1883, and we have since then built and have in use machinery as follows: Three steam dredges

with a capacity of a mile of 6 by 18 feet canal per month each; two ditchers; four traction engines; thirty-two plows, in gangs, having a capacity of 70 acres per day; two steamboats, and nine auxiliary boats—barges, quarter-boats, &c. The traction engines, which furnish all the power for ditching, plowing, cultivating, sowing, reaping, and threshing, are constructed upon the latest improved iron boats, which move readily upon the canals.

In addition to the lands above described there is a vast stretch of sea marsh land from Vermillion Bay to the east line of the State of Louisiana, and extending inland many miles, intersected by numerous bayous, lakes, and bays. Some attempts at reclamation on a considerable scale have been made here. The greatest obstacle in the way of success is the almost annual inundation of this entire region by the floods of the Mississippi.

Mr. Watkins has also furnished the following notes:

The average cost of our dikes, per cubic yard, is 4 cents; of reclaiming, $6 per acre, not including the tide-gate.

The marshes are much richer than the adjacent uplands. They would be excellent for meadows and pastures. The advantages are great depth of rich soil and control of moisture; disadvantages, expense of preparing land for tillage and possibility of trouble and expense with dikes and gates.

We hope to get a full supply of water in from above, and let it out below without much pumping, unless the weather is unfavorable; but we will have our wheels at hand, and the same engines that plow, ditch, cultivate, and reap will drive the water-wheels. The canals will be our roadways for all purposes.

We are fortunate in the matter of fuel; the rivers that flow through our property penetrate the dense forests of pine and other timber north of us, embracing an area of 40,000 square miles, and float the logs to mills adjacent to our estate, where we get fuel of the best quality—pitch pine—without cost.

The Louisiana Land Reclamation Company, being the first to attempt the reclamation and cultivation of large tracts of gulf-tide lands by steam machinery, it was thought especially desirable to embody an account of its operations in this report. Accordingly, the following letter was addressed to the president of the company:

DEPARTMENT OF AGRICULTURE,
Washington, D. C., August 14, 1884.

DEAR SIR: The operations of the Louisiana Land Reclamation Company have been referred to by several correspondents of this Department since the date of my letter of inquiry of November 21, 1883, to which no answer has as yet been received. It is understood that the enterprise did not have a successful issue, and that it has been abandoned.

The magnitude of the project and the large amount of capital invested require that it should be noticed in the report of the Department, now nearly ready for publication, and lest, through omission or otherwise, the work of your company should fail to receive a just recognition, I am induced again to request that you will, if agreeable, furnish as soon as may be convenient, a concise statement for publication.

Very respectfully,

E. A. CARMAN,
Acting Commissioner.

PRESIDENT LOUISIANA LAND RECLAMATION COMPANY,
New Orleans, La.

In response, a copy of the report of Columbus H. Allen, esq., president, to the board of directors, dated July 8, 1884, was kindly furnished. This document is somewhat voluminous, and only those portions which are of general interest are here given.

To obtain a title to the lands described in your charter, 30 miles of canals and levees have been constructed, the former being 20 feet wide, with a depth of 6 feet, and the latter having a height of 5 feet. The boats performed this work at the average rate of 800 linear feet per day, and at an estimated cost of, say, 2½ cents per cubic yard.

The canals drained the water from the lands rapidly, thus testifying practically and eloquently as to the feasibility of your enterprise.

Further gratifying evidence on this score is at hand, furnished by the workings of your plow-boats.

For this system of tilling the lands owned by the company, you are indebted to the intelligence of our able superintendent, Capt. C. J. Allen, who conceived the idea of laying out a tract of this reclaimed land in canals of the width and depth described, running laterally across the tract at intervals of 1,200 feet, and placing these boats in the canals immdiately opposite each other. He fitted them up with a set of Fowler's engines, with the drum upon which they wound underneath. Then constructing plows of his own design, the same were put in operation, and gave the most satisfactory results, thus solving the labor question, and emancipating this company from all dependence upon any other kind of labor than the great motive power steam.

In a similar manner the necessary ditching and harrowing are performed, and all both rapidly and economically; and your board is to be congratulated on the fact that the realms of theory have been abandoned, and that we stand confronted with abundant testimony as to the great success that awaits us financially in the near future.

To come within the law as laid down by the charter, the company was required to reclaim from ordinary tidal overflow 10,000 acres, but, in reality, 13,000 acres were so reclaimed. This was accomplished at a cost of $36,000, or at the rate of a fraction less than $3 per acre.

With the experience of the past to guide us it is confidently believed that future operations in this line of reclamation may be conducted much more economically; but this outlay is comparatively small when the value of the lands so reclaimed is considered. Experts, estimating these lands at their lowest value, rate their worth at $25 per acre.

As this subject may be further elucidated, I beg leave to introduce a letter from the accomplished civil engineer of the company, Mr. Hunter Stewart, who, from a thorough acquaintance with the subject of land reclamation, is fully competent to give an opinion which is entitled to careful consideration at your hands, and should carry with it the weight due to his long experience.

Letter of Mr. Hunter Stewart, civil engineer.

NEW ORLEANS, *July* 3, 1884.

DEAR SIR: Your communication of the 28th ultimo is at hand and contents duly noted. In replying to your questions I have been guided by the data furnished by your company, and in making estimates the average work expected of the plant is based upon the actual work accomplished by your improved dredge during previous seasons, and the cost of a dredge is placed at the same sum as that paid by your company.

Your questions are as follows:

First. What amount of land has the company reclaimed from tidal overflow, and at what cost per acre?

For this information we agreed to have recourse to the officers of the company who have the books of the same in their charge.

Second. If sufficient capital were furnished, together with the necessary plant, the probable average cost to reclaim 100,000 acres owned by the company, in one year's time.

In answering this question I divide it into parts:

(A) According to the present plan of the company, that is, to reclaim 100,000 acres from ordinary tidal overflow and to excavate canals 1,200 feet apart laterally and longitudinal canals 3⅓ miles apart, for use in cultivation, which includes natural drainage and irrigation, and the accommodation of the plow-boats and other craft, the following estimate is made:

An area of 100,000 acres equals 156.2 square miles, or a square 12½ by 12½ miles, which would necessitate five longitudinal canals, or four canals and two front levees on Bayou Penchant (the excavation necessary for the construction of the latter being considered as equal to one canal) and 56 lateral canals.

Lateral and longitudinal canals aggregate 61 canals, of a length of 12½ miles each, which equals 4,026,000 linear feet of canaling; and one dredge-boat excavates 9,000 linear feet per month, or 108,000 feet per year; therefore, 37.28 boats are necessary to accomplish this work in one year.

ESTIMATE OF COST.

37 dredges, at $6,000 per dredge	$222,000 00
37.28 dredges, at $4,800 per year operating	176,900 00
2 tugs and barges	10,000 00
2 tugs and barges (operating expenses)	7,200 00
Supervision and surveys	7,500 00
Contingencies	14,000 00
Total	439,000 00
Cash value of the plant after the completion of the work	155,000 00
Net cost for 100,000 acres	284,600 00
Probable average cost per acre	2 85

(B) According to a revised plan, that is, to place the lateral canals one-third of a mile apart and to leave the rest of the plan unaltered.

This would necessitate 2,871,000 linear feet of canaling, requiring 26.59 dredges to accomplish the work in one year's time.

ESTIMATE OF COST.

26.59 dredges, at $4,800 per year operating	$127,600 00
26 dredges, at $6,000 per dredge	156,000 00
2 tug-boats and barges	10,000 00
2 tug-boats and barges (operating expenses)	7,200 00
Supervision and surveys	7,500 00
Contingencies	9,800 00
Total	318,100 00
Cash value of plant after completion of work	110,600 00
Net cost for 100,000 acres	207,500 00
Probable average cost per acre	2 08

Third. The average number of acres that may be reclaimed, by one dredge-boat properly equipped, per year?

If plan A is followed, one dredge-boat will reclaim 2,682 acres in one year; while if plan B is followed, one dredge-boat will reclaim 3,761 acres per year.

Fourth. The probable number of plow-boats, properly equipped, needed to operate this estate with profit?

Under favorable circumstances the necessary work can be done with 150 sets.

In accordance with your requests for my opinion of the practicability of your undertaking, the subjoined suggestions are made.

In view of the increased discharging capacity of the Atchafalaya River at its head and the great amount of water that flows through its basin in times of flood, carrying, as it does, the majority of the crevasse waters from the Tensas Bottoms, as well as the water overflowing its own front on the Mississippi River and nearly all of Red River, it is very desirable to protect your lands from high waters, especially as

this can be done, in conjunction with the plan of reclamation from tidal overflow, at a comparatively low cost, as the oscillation of the water is small at so short a distance from the Gulf.

From a recent reconnaissance, it is estimated that a levee 6 feet high will effectually protect the track from a flood of the same height as that of 1882, which was the greatest recorded in that section. If the 100,000 acres which are to be reclaimed and prepared for cultivation could be chosen so as to be situated in the most favorable position for economical work, that is, in an undivided square, then a levee 6 feet in height and of proportionate base could be built at a probable cost of $30,000, additional to the cost of reclamation. But as Bayou Penchant crosses the tract diagonally this amount of land cannot be obtained in this manner; still a selection can be made such that the additional cost to construct levees to protect the required area will, in all probability, not exceed $50,000.

The cost of constructing this levee must be regarded as entirely over and above that of reclamation, as the levees or embankments formed by the earth excavated while digging the canals will, owing to the settling and shrinkage, suffice only for the formation of a good foundation or base upon which to build, subsequently, a levee of sufficient height and strength to withstand the pressure of a high water.

Your enterprise has, beyond doubt, emerged from the state of experiment and can now only be regarded in the light of an engineering work needing money and energy alone to be carried to a successful finish. With the necessary mechanical appliances at your command, you have success assured, and the cost of attaining the same is so small that the financial return upon the capital required for a vigorous prosecution of the work will be such as to render an investment in your enterprise a very desirable one. The lands owned by your company are of exceeding richness and well adapted, with the necessary and projected improvements, for cheap and profitable cultivation. Crops of many staple articles can be raised upon them, but they are more especially suited for the cultivation of rice and jute; still, with a thorough system of drainage, which would have to be accomplished by artificial means, there is no reason why any product of the soil common to this latitude should be excluded.

Very respectfully, your obedient servant,

HUNTER STEWART,
Civil Engineer.

COLUMBUS H. ALLEN, Esq.,
President of the Louisiana Land Reclamation Company,
New Orleans, La.

Health is all-important in the successful conduct of enterprises of this nature, and the experience of this company has happily proved to us that no healthier locality exists in the world. Canals have been dug, the crews working day and night, and the men have suffered no inconvenience from so doing.

Under these circumstances, with the means ready at hand to continue the work, both speedily and economically, it certainly cannot be considered the dream of an enthusiast to prophesy the great future of the company.

COLUMBUS H. ALLEN,
President Louisiana Land Reclamation Company.

The following letter was also received from Mr. Allen:

NEW ORLEANS, *August* 30, 1884.

DEAR SIR: In answer to the inquiries contained in your favor of the 26th, I beg leave to submit the following:

We have only reclaimed about 13,000 acres; to do this we constructed, say, 30 miles of canals, of average width, say, 20 feet, with depth of 6 feet.

The prosecution of our work of reclamation was discontinued about two years ago, through the giving away of a number of levees on the Mississippi River in the parish of Point Coupee, the water from these breaks going over our levees and flooding our lands. Additional water was also thrown on us through the deflection of the spring floods of the Mississippi River, a large portion of which flows down the Atchafalaya River, thus flooding our land before escaping to the sea. For further

particulars on this subject see Captain Eads's report on the subject of the Mississippi River cutting itself a new route to the Gulf, via the Atchafalaya River.

Only small experimental crops of 30 acres of rice and about 10 acres of jute were planted by our company in July, 1881. The rice yielded 50 bushels per acre. The jute grew alongside of the rice and in the water, and, being allowed to go to seed, yielded very largely, but cannot state number of bushels per acre, as it was not measured.

No crop on the land at present, owing to causes previously stated—overflows from crevasse on the Mississippi River and surplus water from the Atchafalaya River.

Submitting the above,

Very respectfully,

COLUMBUS H. ALLEN,
President Louisiana Land Reclamation Company.

Hon. E. A. CARMAN,
Acting Commissioner of Agriculture, Washington, D. C.

TEXAS.

JEFFERSON AND ORANGE COUNTIES.

[Judge W. D. Ivey.]

About 91,392 acres, or one-tenth of the whole area of Jefferson and Orange Counties, is subject to overflow during storm tides. Ordinary tides rise about 18 inches, storm tides from 2½ to 3 feet. The marshes are about 24 inches above low water.

The soil is a deposit of shell and vegetable matter, not much sand and no peat. At times the coast is nothing but a mud-bank and very boggy, the sand having been thrown back by the action of the water, leaving the mud exposed.

Stockmen estimate from 2 to 5 acres for each head of stock. The marshes are gradually rising by reason of the heavy growth of marsh grasses. Where there were lakes several feet deep some years ago, grass now grows.

The marshes are entirely owned by private parties. The price ranges from $2 to $5 per acre. None diked.

CHAMBERS COUNTY.

[S. B. Wallis.]

One hundred and forty thousand acres tide marsh in county. Ordinary tides rise 2 feet, storm tides 4 to 6 feet; marsh 3 feet above low water. A great variety of soil, mostly sand and peat, with some black land, clay, clam and oyster shells and gravel. Used for stock-raising; 3 acres allowed per head. Belongs almost entirely to private parties; value from $1 to $10 per acre; average value $3. A great portion is so situated that tides could be excluded with very little expense.

[Hugh Jackson.]

This land is used exclusively for grazing, especially for winter grazing, and is far more valuable for that purpose than any other it could be used for if reclaimed, as far as is known or believed by the owners

of the marshes. Choice marsh land sells for $2 to $3 per acre, and after being inclosed (fenced) in connection with high land, as is most of it in this county, is considered worth $5. Ordinarily sales of uninclosed marsh do not reach much higher than $1.50 per acre. Stock owners and raisers now own all of it in this county, and they will not sell, and do not want it reclaimed. It is considered better as it is for winter pasture. We have very few storms and low tides during the winter season. The marshes afford green grass throughout the most severe winter and are excellent grazing lands.

[L. G. Chambers.]

Most of the marshes in this county could be reclaimed and would produce from one and a half to two bales of cotton per acre. They are all owned by large cattle-owners and used for winter pasture, and are worth double the value of the adjoining uplands.

[James Jackson.]

A belt of country along the shore of East Bay, ranging from 1 mile to 5 miles wide and 20 miles long, is all marsh. A large portion is not overflowed by common tides, but every high tide covers most of it. Cattle graze upon and alligators breed in it. Many persons hunt the alligators for their skins.

GALVESTON COUNTY.

[O. Gareissen.]

Twenty thousand acres of tide marshes in the county. General elevation above low water about 1 foot; common rise of the tides, 1 foot; east storm tides rise 5½ feet; north storms lower the water 5 feet; normal tide very weak—controlled by wind. The marshes on Galveston Island are owned in small tracts; on the mainland, along Galo Bay, in large tracts. They are mostly alluvial; small parts peaty. Vegetation is salt grass, valuable for early winter pasture. The marshes are connected with dry land, and sell, with them, at 75 cents to $1.50 per acre. None diked, as land with timber and fresh water can be had cheap near by. The abundance of cheap dry lands would prevent reclaimed lands from getting a value in proportion to the expense of reclamation. Otherwise there are no insuperable obstacles to reclamation.

BRAZORIA COUNTY.

[A. Metcalfe.]

Large bodies have lately been sold for $2 per acre; these rates include both marsh and upland. No lands of any kind have been reclaimed in this county. The general impression is that these lands can be easily reclaimed, but owners are, as a general rule, perfectly satisfied to use them for grazing. The coast line of this county extends 45 miles, and the marshes 5 miles inland.

[William A. Rowan.]

This is strictly a stock-raising country. Our lands are mostly prairie, with belts of timber. Creeks, or bayous, running inland are bordered with a heavy growth of timber above the salt-water tide. The land rises from 1 to 10 feet in a distance of 10 miles inland from the bay.

Dotted over the prairie are marshes or sunken tracts of land, in some places several hundred acres. Grasses on such tracts are fresh; those along the bays of Galveston and Chocolate are salt. There is an abundance of arable land, and we value the marshes more highly for stock-raising than for farming; marshes are worth 50 cents to $10 per acre.

[Hennell Stevens.]

Not over 1,000 acres are regularly overflowed by the tide. On the Gulf the land averages 3 feet above high tide, and rises a foot to the mile. There is an almost complete chain of bayous or lakes inside the coast line; common rise of the tides, 2 feet. In 1875 and 1854 we had storms with tides 6 feet higher. Marshes are generally owned in large tracts. The soil is almost entirely a stiff clay—no rock for 600 feet down.

MATAGORDA COUNTY.

[John Matthews.]

These lands are generally valued by leagues, some of which contain more marsh and flats than others, and prices vary greatly according to connections with other lands. They are never, and could not be, sold alone at any price; none diked.

[H. E. Moore.]

Twenty-five thousand acres of marsh in this county, valued at $1 per acre. The low, flat country and marshes are principally owned and fenced by large stock-raisers, and, as we are not subject to storms during the winter season, the wire grass affords fine winter pasturage.

The land could no doubt be made very productive, though we have plenty of fine farming lands vacant that could be bought at $2 to $5 per acre.

VICTORIA COUNTY.

[Dr. T. R. Cocke.]

In the extreme southern part are several thousand acres of salt marsh, but not affected by tides. This land is used for grazing; nominal price, $1 per acre; mostly sandy soil.

CALHOUN COUNTY.

[J. M. Bickford.]

Twenty-five thousand acres; value, $2 to $5 per acre; none diked. This is a stock-raising county; very few small farmers. Stockmen are glad to have some marshes in their pasture for a change during the extreme low tides, and for a winter range.

REFUGIO COUNTY.

[William A. Blodgett.]

The tides of our inland bays, bayous, and rivers are the result more of wind-currents than tide-currents. Think a foot rise by tide quite up to the average on the Gulf. With a wind off-shore the tide is not felt inland.

[John Gray.]

The tide lands belong to the State. The owners of adjoining lands are permitted to fence and occupy them as pastures, but hold no title.

[E. M. Phelps.]

Twenty thousand acres of marshes in Refugio County, at the mouth of the Guadaloupe River, are undoubtedly of great value, being formed by deposit, but are now subject to overflow from the river, and during severe storms are flooded by the tide. A levee 4 feet high would reclaim two-thirds of this tract, with some means of getting rid of the rainfall.

NUECES COUNTY.

[Joseph Fitz Simmons.]

Thirty thousand acres of tide marsh along the Nueces River and bay front; assessed at $1; used for pasture; none diked.

CAMERON COUNTY.

[J. J. Cocke.]

No marshes. One hundred and fifty thousand acres of worthless *salt flats;* hard when dry. No vegetation except occasional small patches of a salty weed or grass. Uplands, 50 cents. Large tracts might be leveed and permitted to dry out, but when dry the earth would be found so impregnated with salt that nothing would grow. In fact, the whole of Cameron County is salty; in many places fresh wells cannot be had. The quantity of salt flats, estimated above, includes parts of the Laguna Madre, one-half of which is sometimes dry for months together.

CALIFORNIA.

[Edwin F. Smith, State statistical agent for the Department of Agriculture.]

This enterprise (reclamation) has been carried on to the greatest extent and most successfully in that section known as "the delta," which lies at and near the confluence of the Sacramento and San Joaquin Rivers. There are about 600,000 acres of swamp and overflowed lands in this delta. A very large sum of money has been expended in attempts at reclamation, most of which have been failures, owing solely to economy in expenditure. Many started with the idea that from $5 to $10 per acre would reclaim their lands, and built levees accordingly. They invariably came to grief. No complete reclamations have been made near the junction of these rivers. The best in the State is that of Williams and Bixler, on the upper end of Union Island, a very complete reclamation of 11,000 acres. They are now at work upon the lower section, of about 21,000 acres.

Nearly all the lands of the delta are susceptible of reclamation, and upon fair terms, but the laws relating to the business are so imperfect that enterprising men and capitalists are afraid to embark in it.

The cost of reclamation is dependent upon so many things that it is difficult to give figures. Great improvements are being made in machinery for such work, and people are beginning to learn that they must incur expenses more nearly approaching the value of their lands than heretofore. I send a list of the lands that have been reclaimed. The cost of reclaiming these lands has been, upon an average, $30 per acre; the value of land, which prior to reclamation was $5, is $75 to $100 per acre. These lands are inexhaustible, and for fruit, vegetables, and grain cannot be excelled. The greatest drawback is the continuous flow of "slickens" from the mines. Lands have been reclaimed as follows:

Sacramento County.—Pierson reclamation district contains about 8,000 acres; east side of Sacramento River from near Courtland to Walnut Grove is all well reclaimed, and nearly all in cultivation; about 2,000 acres orchard, all as fine land as is in the United States. Grant Island, between the Steamboat Slough and Old River (two of the three mouths of the Sacramento) containing about 20,000 acres, is partially reclaimed; about 3,000 acres orchard is susceptible of first class reclamation and very valuable. Andrews Island, between Old River and Georgiana Slough (two of the three mouths of the Sacramento River), area about 8,000 acres, is partially reclaimed; about 6,000 acres in cultivation, 600 acres orchard. Brannan Island, between Sacramento and Mokelumne Rivers, contains about 10,000 acres, 500 acres in cultivation. Its reclamation has not been successful. Sherman Island, between Sacramento and San Joaquin Rivers, contains about 16,000 acres. Its reclamation has not been successful, and I think is impracticable. Tyler Island, between Georgiana Slough and the Mokelumne River, contains about 8,000 acres; 2,200 acres well reclaimed and in cultivation; 300 acres orchard; all susceptible of perfect reclamation and very valuable.

San Joaquin County.—Staten Island, between the north and south forks of the Mokelumne River, contains about 1,200 acres; is reclaimed and in cultivation. Union Island: Tide Land Reclamation Company have reclaimed 11,000 acres successfully; about 2,100 more to be reclaimed. Robert's Island: Glasgow California Land Company have reclaimed successfully about 20,000 acres. Boulden Island, between Mokelumne and San Joaquin Rivers, contains about 6,000 acres; is reclaimed and in cultivation.

[James T. Stratton, deputy surveyor-general.]

The Census Report gives a somewhat exaggerated impression about the results of reclamation on our *salt marshes.* I have been familiar with these lands for thirty-two years, and have watched the progress of reclamation with a great deal of interest, and I regret to have to say that it has not met my expectations. Small patches of 50 or 100 acres that have been freshened by turning into them the waters of some neighboring stream, which has also left a deposit of sand and mud, have produced fair crops, and will of course continue to improve, but where attempts have been made to reclaim large bodies of these lands results have not been satisfactory. That they will all be thoroughly reclaimed in course of time and become very valuable for vegetables and grasses I have no doubt, but those who expected an easy and rapid reclamation have been disappointed.

There are about 70,000 acres of these lands around the Bay of San Francisco, and probably 10,000 acres around the other bays. They have

nearly all been sold by the State at $1 per acre, which is repaid to purchasers when reclamation is completed, or when $2 per acre has been expended.

There are immense bodies of fresh-water marshes along the Sacramento and San Joaquin Rivers—about 1,000,000 acres, 50,000 of which have been reclaimed. These are among the most valuable lands in the State, but for the great mass of marshes complete reclamation is impossible, they being subject during the winter to floods from 5 to 15 feet deep. After the river channels shall have become cleared of the mining *débris* with which they are now obstructed, the reclamation of the marshes will again be attempted, and no doubt a large proportion of them will ultimately be completely protected from overflow, but it is generally regarded as a question for the next generation to solve.

Our *salt* marshes are exactly at the level of ordinary high tide, and the spring tides never rise over them more than 2 feet. The ordinary rise and fall of the tide is about 5½ feet.

NAPA COUNTY.

[John Kean, county assessor.]

There have been attempts to levee or dike nearly all the marsh land in this county, but the levees were not built strong enough to resist the pressure of the tides, John A. Stanly being the only one that reclaimed his land.

[John A. Stanly.]

My reclaimed land, and that on the Napa River generally, is for the first 6 inches a soddy turf. Under this, for several feet, the soil is of decomposed vegetable matter, intermixed with sediment. Next is a bed of blue clay, the thickness of which I have not yet ascertained, having bored into it to a depth of over 200 feet.

Before reclamation *all* the land was covered by the spring tides, and a very large part by every high tide. Ordinary tides rise and fall about 8 feet; storm tides rise 5 feet higher, but this only in the conjunction of a spring tide with a freshet or flood in the river.

Material for dikes should always be taken from inside. This land is worthless for agricultural purposes unless drained, and the ditches from which the material is taken are indispensable in aid of this purpose. My dikes are 16 to 20 feet at the base, 5 feet high, and 4 feet on top. The slopes were formed of the first cut taken from the ditch, grass outside, and laid so as to break joints; the sods were cut about 15 inches long and 8 inches square. The space between these walls or slopes was filled with the mud taken from the ditch, which was thoroughly tramped. About midway the base of the dike, and for its whole length, a small ditch, about 12 inches square, was dug in advance, to act as a key and prevent any seepage under the dike. This, I think, is preferable to removing all the turf under the dike.

I have tried two kinds of sluices, one entirely covered by the levee or dike, and the other open from the top. The open sluice is more permanent and less expensive to keep in order, although costing more in the first instance than the other. I will try to describe one. The ditch inside the dike being 6 feet deep, the levee or dike 5 feet high, and the sluiceway to be 8 feet wide, I excavate from the ditch to the river a canal 9 feet wide, the bottom of the excavation for the first 24 feet being on a level, and from thence to the river with a gradual fall. Commencing

on a line with the inside of the dike I drive piles, 8 by 8 inches by 24 feet, 30 inches from center to center, on each side of the excavation for 24 feet. This puts 13 feet of the piles under the bottom of the excavation, and 11 feet above to the top of the dike. Across the bottom of the excavation sills, 3 by 8 inches, are gained in the piles and spiked, and the tops of the piles are tied together in a similar manner. The two end sills and the middle one are then sheet-piled with 2-inch plank to the depth of 5 or 6 feet. It is then floored and sided with 2-inch plank put on with composition spikes. A gate made of 2-inch plank, lined with 1-inch boards, is then hung on the outer end, from which to the river (generally 40 to 60 feet) the canal-way is floored with 2-inch plank and the sides sheet-piled with the same. The outer end should be placed at low-water mark and sheet-piled as deep as possible. Sluice boxes, gates, and ways made after this fashion have stood the test of ten years floods without expense, and are as good as when first made.

Mine being the only land reclaimed in my vicinity, there is no "common method" of treatment. My own treatment was a series of mistakes, which had the natural result of costing a great deal of money unnecessarily. I can only say, generally, the land should be plowed as soon after the tide-water is excluded as possible. It should be drained at the same time. Unplowed and undrained it is worthless. The salt grass dies out the first year and is succeeded by nothing of value. In a year or two after the tide is excluded the land breaks up, opens immense cracks, and is very difficult to plow. With me, it required twelve oxen and two men to work a single 14-inch plow.

The land being drained and plowed *immediately* after the tide is excluded, I think the best plan would be to cut it up as well as possible with a rolling coulter harrow, and seed down to rye for three or four years. The first year the crop will be light. The second crop on my land was about seven tons to the acre of rye hay. In this climate, where we have no freezing, and no succession of wet and dry weather, it takes several years to get the land in tilth, and then it is good for anything that grows in this climate, but I think most valuable for grass. Such land is better than uplands for any farming purpose and immeasurably superior for pasturage.

I have tried timothy, red top, mesquite, blue grass, alfalfa, rye grass, and orchard grass. The first four were failures. Alfalfa does tolerably well, but there is too much permanent mositure in the land for its habit. Rye grass (perennial) does admirably, stays and increases. Orchard grass is the best of all, but expensive. From a light seeding, rye grass spreads and takes possession, but if you fail to get a stand of orchard grass it can only be had by reseeding.

The principal advantage of marsh land consists in its inexhaustible fertility. A local advantage, incident to my land, is the facility of irrigating it in June and July, when the tide-water is fresh, thereby giving a new growth of grass when the grass on uplands is dry.

SAN JOAQUIN COUNTY.

[Thomas H. Williams.]

The delta of the Sacramento and San Joaquin embraces about 700,000 acres of the most productive land in the State, the greater part capable of reclamation at a cost far below the value of the lands when reclaimed.

Various attempts at the reclamation of large tracts have been made, with only partial success. The failures have been chiefly due to ignorance of the business on the part of persons engaged in it, and the defective laws of the State pertaining to the subject. In the first respect rapid improvement is being made, but in the latter there is little hope, if any, in the near future.

Up to this time, the area of lands which may be deemed secure against the greatest known floods does not exceed 25,000 acres. Seventy-five thousand acres will embrace all that is partially reclaimed, and upon which occasional crops are made. Messrs. Williams and Bixler have the most perfect reclamation on Union Island which has been made in the delta. They now have in cultivation 11,000 acres, and expect to complete the reclamation of another section of 12,000 acres within a year, and another of 9,000 acres in the succeeding year. They also own other large tracts, some of which are partially reclaimed.

I have examined the dikes in several countries, and the official reports relating to most of them, and feel safe in saying that there are few, if any, places where reclamation can be more thoroughly and cheaply made than in the greater part of the delta of California. There is not a district of 6,000 acres and upwards that, to make a complete reclamation, would cost exceeding $50 per acre, and much could be reclaimed for $30, and perhaps less: and when reclaimed those lands pay good interest on $100 to $400 per acre.

The unreclaimed lands sell from $5 to $25 per acre, depending upon locality and surroundings. Those completely reclaimed are valued at $100 to $125 per acre. Assessments for taxation range from $3 to $35 per acre, except in case of orchard lands, which are rated much higher.

These lands produce all the cereals, fruits, and grasses adapted to this climate. My impression is that most of them will eventually be used for fruits and grasses. Orchards bring an income of from $50 to $400 per acre, and grass lands from $15 to $25 per acre.

I am less familiar with salt marshes than with the fresh-water lands, but have examined several tracts and am satisfied that they can be easily reclaimed. But few reclamations, and those small, have been made; enough, however, to satisfy me that they will all be reclaimed before many years shall pass, and become very valuable. As a rough guess I would say that there are about 200,000 acres of salt-marsh lands bordering on the bay of San Francisco.

We use two dredging machines on floating scows. The excavator of the "Atlas" is a cylinder with buckets on the periphery, and is placed at the end of a frame which projects about 35 feet beyond the bow of the scow. It is propelled at the rate of 20 to 50 revolutions per minute by a 30 horse-power engine, which sets on the frame. The excavated material falls with water into the wheel, and is taken from there in suspension, through a suction pipe 20 inches in diameter, to a runner inside of the scow. This runner is a sort of vertical turbine, and is propelled by a large engine inside of the scow, which makes about 180 revolutions per minute, forcing the excavated material through a pipe, 18 inches in diameter, to the shore. The greatest distance we have carried material by that process is about 300 feet. It can be carried much farther, depending entirely upon the force applied. This machine is especially valuable for the removal of débris from water-courses. It cost about $50,000.

The other machine, the "Hercules Dredger," is much more powerful. The material is excavated by a series of dipper-buckets on an endless chain, and dropped in a hopper about 40 feet above the deck of the

scow. From the hopper it passes by gravitation through a pipe, 30 inches in diameter, to the place of deposit. By gravitation alone the material can be carried 120 feet from the scow. By adding water it might be carried several hundred feet, but there is no need, ordinarily, to carry it over 100 feet. The material falls with great force, making a very compact levee—the best we have, and certainly the cheapest. This machine can be used in the bed of a stream, or on its banks, or to excavate canals. We have used it principally in the latter work, where it performs the double office of making navigable canals and reclamation dikes. It has been at work over three years with great success, and is now used by the American Dredging Company on the Panama Canal. In the ordinary material of our tide land it will excavate about 400 cubic yards an hour. We are now building an improved machine, worth about $100,000, which I think will reach 500 cubic yards. As might be expected, delays in the work occur from all sorts of causes, but it is safe to say that we average twelve out of the twenty-four hours the year through, and with the new machine will reach at least sixteen —I think twenty.

Prior to the introduction of these machines we constructed dikes by hand with wheelbarrows, and with horses and scrapers, the cost ranging from 10 to 20 cents per cubic yard. We made nice surfaces and exact lines, being careful not to put in more material than was absolutely necessary. Now we pay no attention to those things, but let the material fall and lie as the machines dump it, and keep piling it up until a suitable height is obtained. As a consequence, we get in place from two to five times as much material as by the old method. The dike is rough and uncouth, but the best that could be made, and the cost per linear yard does not exceed that of the old method. On good banks, with good material, our dikes are built upon the plan of 5 feet crown, and slopes of 4 upon 1 on the outside, and 3 upon 1 on the inside, the height and base being, therefore, dependent upon locality. When the banks are not strong or the material is light the dimensions must be increased.

Redwood sluices and gates have heretofore been used in this country, but they are both perishable and unsafe. My plan now is to make tubes of boiler-iron, place cast-iron gates at each end, and two or three wide flanges around the pipe, and pack in closely around the pipe with clay before replacing the levee material. Well made and dipped pipes of that character will last a generation and be perfectly safe.

The effect of hydraulic mining upon the fresh-water tide lands is variously estimated by the people according to their interests and situations. It has unquestionably ruined large and valuable tracts of land in the vicinity of Marysville, but has not done much injury below Sacramento City. No particular harm has resulted from mining on the headwaters of the San Joaquin River. Should hydraulic mining be continued as in the past it will greatly retard, if not prevent, the reclamation of the swamp lands in the region of and below Marysville. The effect of stopping such work will be to enable the rivers, in time, to assume something near their normal condition, except near their entrance into the bays, where, as well as in the upper bays, navigation has been and always will be greatly impeded.

I predict a complete reclamation of the entire Sacramento and San Joaquin delta and the salt marshes of the San Francisco Bay within 30 years, a territory capable of supporting a population greater than that of the State at the present time.

[John W. Ferris.]

Our marshes consist of alluvial deposit, with occasional intermixture of peat. They are overflowed at spring tides only, before reclamation. The surface of the land, therefore, is a few inches above ordinary high-water mark, and 5 feet above ordinary low water. The highest storm tides rise 26 inches above the average level of the land on the creek banks.

The dikes, or, as locally termed, "levees," are always constructed from material excavated from the marsh. Two reasons forcibly determine the location of the levee outside the spoil ditch, first, the ditch when dug of sufficient depth forms the main drain of the intake, connecting by flood-gates with the outer creeks, and fed by smaller subsidiary drains running to it; second, the newly-cut surfaces of the ditch, if outside of the levee, are immediately burrowed by myriads of small crabs that work in the limit between high and low water.

Levees built of material excavated from the marshes, which is necessarily surcharged with water, are found to crack very much at dry seasons. To obviate leakage the surfaces require to be kept well harrowed. This is only possible on a slope of three base to one elevation, and three to one slopes are therefore correct, where wave action has not to be resisted. The height should be not less than 2 feet above highest water mark, and the crown, if given a width of 8 feet, may be used as a roadway. All growth and rubbish should be removed from the front portion of the levee base, but it is not found desirable here to break the ground surface.

The best form of sluice-gate is that which, from its construction, offers the least frictional resistance to the flow of water from within, provides sufficient resistance to the hydrostatic pressure from without, and offers proper obstruction to the passage of water, over, under, or alongside it. Well-selected timber will be preserved by the salt, and is therefore quite sufficient without necessitating the cost of masonry. The teredo does not affect the timbers in the upper part of the bay. None but galvanized spikes and nails must be used, as unprotected iron rusts out in about four years. Inclosed I beg to hand you a tracing of the gate I find most serviceable in the salt marsh (Fig. X). Its cost, including setting in site, is a little under $200. The water-side gate is automatic, and on the land side is placed a "dead" gate to close down in case of any accident to the swinging gate or flume.

The points of excellence claimed for this form of gate are (*a*) the gradual narrowing to the flume proper, which is made as short as practicable, (*b*) the proper flare to the outer apron to reduce in best possible manner the velocity of water discharging through flume and avoid the cut which would otherwise be set up over the front edge of apron, (*c*) absence of projections in aprons and flume by which eddies are set up and efficient discharge greatly diminished.

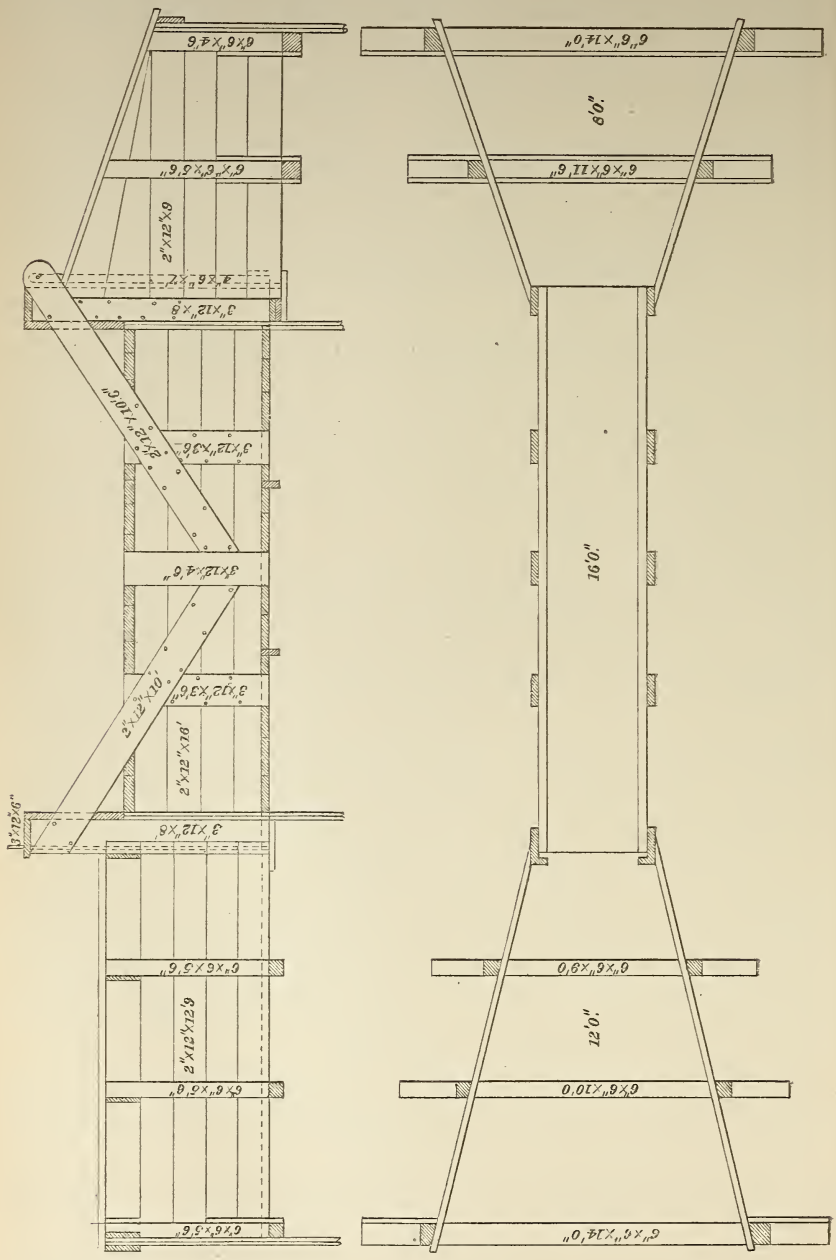
The greatest possible care should at all times be taken in the setting of these gates to avoid leaving spaces around the plane timber surfaces for the passage of water, and the sheet-piling must also have joints carefully broken with the same object in view.

Automatic sluice-gates vent the water in a perfectly satisfactory manner; further complications, such as siphons, pumps, &c., are therefore unnecessary.

There are no muskrats in California. The gopher, or pouched rat, has a predilection for levees, but very moderate carefulness prevents any serious consequences. No iron plates or other means of any sort

are necessary to prevent burrowing, provided always the levees be of proper size.

The average cost per cubic yard of constructing levees on salt marshes in California is 10 to 12 cents. The average cost per acre for diking or



leveeing, subsequent draining, filling the smaller creeks that have to be crossed by the plow, the first breaking of the land, and other similar

expenses that are chargeable to capital account, is about $25 per acre.

Marshes should be plowed as quickly after reclamation as the ground becomes solid enough to carry stock and before the inevitable cracking, that the shrinkage of the soil in drying induces, has gone very far. Shallow plowing for the first year is preferable, say to a depth of 3 or 4 inches, the surface growth being removed before plows are started. Summer fallowing for the first crop is good practice, as the furrow will then easily work down the ensuing fall. Rye, oats, and barley are the best first-year crops, a most important point to observe being to sow early and get the full benefit of the winter's rains. Each subsequent year the plowing is a little deeper, and three or four years should show 8 or 9 inches of well pulverized soil, mellow and easily worked, free from any excess of salt, and able to show good results.

Hay grown on (reclaimed) salt marsh will be preferred to any other as soon as consumers become familiar with it, the salt it contains making it so palatable to stock that much less is wasted than of other hay.*

All water-logged soils are affected by drought, and for the first year or two after reclamation marsh lands will necessarily be so affected. As drainage is perfected and the soil thoroughly comminuted and pulverized, the land becomes very much less subject to injury from drought than upland.

The ultimate application of these lands is undoubtedly pasture—the three or four years general farming after reclamation being simply with the aim of getting the land in suitable condition for sowing grass seeds. Reclaimed salt marshes in Holland, England, in fact the world over, are the best beef-producing lands known, and experience in California marshes shows that when properly reclaimed, drained, and put in thorough cultivation before laying down to pasture, the land may be relied on to carry one head per acre, and where the water is not so brackish as to permit flooding for irrigation in June, as is the case generally with land in the North Bay of San Francisco, considerably better than this will be done.

Perennial rye grass serves admirably, and is as good a grass as can be desired.

Reclaimed marshes will at first be readily sodden with heavy rains, but in two or three years with good cultivation their absorptive power becomes immensely increased, and where sufficient floodgate area is provided no difficulty is found in handling even the heavy rains of the coast counties.

Salt marsh lands in California have yet to redeem themselves from the stigma of uncertainty gained for them by early reclamations. It is quite certain, however, that the problem of their reclamation is one of the simplest, and this fact is fast becoming recognized. There is here no "unknown factor" to deal with; the greatest known flood

* A sample of such hay, forwarded by Mr. Ferris, was examined by Dr. Richardson, Assistant Chemist of the Department of Agriculture, who reports as follows: "The sample of salt hay which was sent to the Department by J. W. Ferris, Stockton, Cal., for examination has been analyzed with the following results:

"A portion of the hay was burned and found to contain chlorine 1.08 per cent.

"I have never found a larger amount in but three grasses, and Wolff gives but three with higher percentage.

"A portion treated with water for a minute allowed the greater part of the chlorides to dissolve, and chlorine was found in the water extract, 1.00; extracted hay, .17; total, 1.17.

"The chlorides, therefore, are readily soluble. I should hesitate, however, to conclude that they were therefore merely physically a mixture with the hay, and should prefer to accept the idea that the pure ash of the hay was actually in itself rich in these salts."

height is but 2 feet over ordinary high tides; the material is perfect and the foundation good. These facts will speedily dispel the prejudice existing amongst capitalists against the marshes, and their value will be the amount of money they can pay fair interest upon.

All marshes bearing a healthy growth of samphire, spear grass, or round tule, may be considered fit for reclamation, avoiding only those that are distinctly and entirely peat, whose growth denotes the presence of too much alkali, or where the deposit is too recent, as evidenced by the growth of the three-cornered tule only. At time of reclamation marshes should have an elevation of 5 feet above low water, to allow, after the inevitable settling following reclamation, sufficient fall for drainage. There is no question as to the practicability of reclaiming land with less than 5 feet of tide action, but to insure sufficient water-carrying ability to the main drains they must have plenty of width.

I have recently built a dredger for salt marsh reclamation, and, after carefully considering the requirements, designed her to cut a ditch 20 feet wide and 6 or 7 feet deep. The material thus excavated is more than is required for the levee or dike, but the large ditch is a great consideration. The reason for this is that if small gates be placed at frequent intervals, the discharge being small at dry periods, the race-way in front of gate is liable to be silted up, and a constant expense thereby necessitated. Consequently, in leading the water a long distance, say 2 miles, to a larger gate, the ground being on a dead level, it is not possible to get current velocity enough in a small cut, and width has therefore to be depended on to overcome the difficulty. The settlement after reclamation is always much less at the water's edge than elsewhere, because the greater deposit here makes the land more solid. This settlement consequently leaves the land saucer-shaped, and an apparent 5-foot margin available for drainage before reclamation will be but about 3 feet after cultivation, in the middle of the tract.

Windmills are good as auxiliaries, but not safe alone; the wind has an unfortunate predilection for failing at critical times. Steam pumping is not so expensive as may be supposed. Outside the interest, wear and tear, and depreciation of plant, the cost of pumping on a tract of land with which I was familiar in England aggregated only about 25 cents per acre yearly.

Where much exposed to storms a sufficient foreland with its natural coarse growth will nearly always give sufficient protection, provided always a sufficient slope be given the levee on the water side.

There are large areas of unimproved marsh on the bay of San Pablo and its confluents, and owners are watching the results of thorough reclamation.

Where attempts at reclamation have not been successful, failure has resulted chiefly from insufficiency of the levees, and ignoring the absolute necessity of subsequent drainage.

The natural growth of salt marshes has some little value for pasturage, only when accessible from an adjoining upland.

In California the swamp and overflowed lands were deeded by the Federal Government to the State. Most of them have since been "taken up" by individuals.

There has been no noticeable elevation or depression of lands along the coast so far as I am aware. There is a tradition that the water level is receding, but I can offer no opinion as to its correctness.

The usual increase of malaria attending on the first cultivation of a reclaimed swamp is not observed here, owing doubtless to the rigorous trade winds that blow from the ocean with great regularity during the

summer months. One noticeable consequence of reclamation, however, is the comparative abatement of the mosquito nuisance.

The recent decision of Judge Sawyer will not immediately affect the tide marshes proper, but will be of immense importance as affecting those situated farther up the rivers, where, besides simple rise and fall of tides, the flood water has to be handled.

SONOMA COUNTY.

[Frank H. Denman.]

About twenty-five thousand acres of tide marsh in the county; elevation above low water 5½ to 7½ feet, according to distance from San Pablo Bay; common rise of the tides, 6 to 8 feet; storm tides just after a hard rain, 2 to 4 feet higher. The marshes are generally owned in large tracts, 19,000 acres being in eight tracts, each exceeding 1,000 acres. They are chiefly peaty. Vegetation, salt grass, with thick, fleshy branches, triangular sedge, and tules; not used for anything; stock will not eat it.

Unimproved marsh, if not too much cut up by sloughs, sells for $15 to $20 per acre; average value of adjoining upland (selling price) $100 per acre.

The marsh land is located in the southern end of the county, bordering on Napa Slough on the east, San Pablo Bay on the south, and Petaluma Creek and upland on the west. The Sonoma Valley Railroad crosses a part of the reclaimed land of the San Pablo Land Company, the soil being of sufficient firmness to sustain the track. The San Francisco and North Pacific Railroad crosses the unimproved marsh on the west side of Petaluma Creek. There the road-bed is gradually settling. I have noticed where large sloughs were being dammed the bottom immediately above and below was bulged up, showing the material under the crust to be quite soft; a man could thrust an inch pole down 25 feet.

CONTRA COSTA COUNTY.

[A. J. Biglow.]

One hundred thousand acres, chiefly salt marsh and peaty, 4 to 5 feet above low water. Common tides rise 5 to 6 feet; storm tides, 6 to 8 inches higher. Marshes used for grazing. Vegetation, tule and salt grass. Owned in large tracts, valued at 50 cents to $1; uplands, $10 to $50; valuations obtained from county assessor. Three or four thousand acres fresh-water tide lands on the San Joaquin River partially reclaimed in small tracts within the last eight years; good success for the amount of work done; dikes not sufficient to keep out storm tides. The principal obstacle in the way of success is the want of a law to compel all owners to bear expense in proportion to area of land and benefit derived.

SACRAMENTO COUNTY.

[A. J. Biglow.]

Commenced in the fall of 1861 on Sherman Island, and made a success of it so long as we kept up the dikes. The island contains about 14,000 acres. After it was diked and the wild vegetation subdued, we found it well adapted to almost any kind of crop. It was owned gen-

erally in small tracts; the State law proved insufficient to compel all land owners to pay, and one after another became demoralized and failed to contribute to keep up the levees. Utter ruin has followed, and to-day there is a lake where ten years ago was a prosperous community with immense crops of everything that could be produced in this climate. Sherman Island, on the north bank of San Joaquin River, was among the first to demonstrate success, and then failure—failure from want of unity of action.

ALAMEDA COUNTY.

[John A. Plummer.]

An English company owns all the marsh at this end of the county. Speculation has put a fictitious price on this land far above its actual worth. It was reported that $15 per acre was paid by the English company. Adjoining uplands, which are more or less impregnated with salts, or, as commonly called, alkali, sell for $25, though very little if any in this section is for sale. Good land ranges from $75 upwards, as it extends inland.

This salt marsh cannot be reclaimed unless flooded with fresh water. Artesian wells have been sunk in several places on the adjoining upland, but the results are, I think, unsatisfactory.

[Eder F. Dyer.]

Mr. Lewis Smith has reclaimed 100 acres by diking and flooding with artesian well water. Mr. Helwig about 10 acres; both met with good success. The passage of a law to prevent the use of artesian wells in reclaiming land is probable.

MONTEREY COUNTY.

[S. N. Laughlin.]

Marshes 3 feet above low water; rise of common tides the same; storm tides 1 to 2 feet higher. Recent sales of 500 acres at $5 per acre; adjoining upland worth $40 to $60. No marshes reclaimed, but I have made arrangements to reclaim a tract of 1,500 to 2,000 acres by diking to keep the tide out and digging a canal to turn a fresh-water stream upon it. If keeping the tides off will make good lands a large tract in this section can be easily reclaimed.

OREGON.

CLATSOP COUNTY.

[D. K. Warren.]

The tide lands in this vicinity are of two distinct formations. Those bordering the streams, rivers, and bays consist of a stiff muck, formed by the sediment from the rivers, together with the annual decay of vegetation from the soil and a small percentage of sand, and are what we term clay lands. This formation is from 3 to 4 feet deep, resting upon a subsoil of slate-colored clay of unknown depth. Lands of the other class are called peat or beaver-dam lands. They are found adjacent to

the high lands around the heads of tide sloughs, and farther inland. These lands seem to be composed almost entirely of vegetable matter, range from 3 to 10 feet in depth, and usually rest upon sand.

The tide lands have an elevation of about 1 foot above ordinary high tide, the mean rise of which is about 6½ feet. Sometimes southerly storms in winter cause the water to rise 4 to 4½ feet higher, or more than 3 feet above the surface.

The dimensions of my dikes are, base 10 feet, height 5 feet, and top 4 feet. They are constructed from material adjacent, *i. e.*, a ditch is cut on each side of the dike, two feet from the base of the same, sufficient in width and depth to furnish the requisite material. It is unnecessary to remove the turf from the surface before constructing the dike.

My sluice-ways are placed in, or adjacent to, the large sloughs crossed by the dike, and are constructed of plank 18 inches wide and 3 inches thick. The bottom is the width of two planks, which rest on and are securely spiked to cross-timbers well bedded; the sides are of single planks, the top covered with the same material laid crosswise, and the whole well spiked together. The gates are on the outer end of the sluice, hung on wooden hinges 3 feet above the box, to prevent them from floating before the incoming tide is strong enough to force them shut.

My dike is 2 miles long, was built in 1879, and reclaims 325 acres. It crosses ten sloughs, which vary in width from 20 to 100 feet, and are of an average depth of about 8 feet. These sloughs or tide streams are dammed with material like that of which the dike is constructed, with the addition of sufficient brush to hold the mass together. No piles or planks are necessary. The dams are 40 feet wide in the bed of the stream, and 20 feet at the surface of the marsh, and on this foundation the dike is constructed the same as on the land, leaving a berme 5 feet wide on each side. My dike was experimental, but after a trial of nearly five years it is a success in every particular. There is no seepage, and the tide gates, nine in number, work well and give ample drainage.

We have taken no precaution against muskrats, which alone give us any trouble; the damage by them has not exceeded $5 per annum on 2 miles of dike.

The average cost of constructing dikes similar to mine, with wages at $2 per day, would be about $5 per rod and 25 cents per cubic yard for damming sloughs. The cost per acre would be from $5 to $10 for reclaiming land in large tracts, say from 500 to several thousand acres.

Where failures have occurred they have resulted from lack of money or muscle. There is no trouble in making reclamation a success in this section, if dikes are built of sufficient dimensions to withstand the pressure of 3½ or possibly 4 feet of water. The material for their construction, the clay above described, is the very best for that purpose. The cost of building and maintaining dikes through peat, or beaver-dam lands, would be somewhat greater than the above estimate, in consequence of the material being too light and inclined to shrink and settle in the process of decomposition; but it is seldom necessary to construct dikes on peat land in this vicinity, because clay is invariably found along the front or shore line of the bays and rivers.

The treatment of reclaimed land is similar to that of other prairie land, with, perhaps, this exception—while the prairies of the West are usually broken during the early summer months, these lands can be broken at any season. My method is to sow oats on all that is broken in winter and spring, prior to the first of June, and after harvest to

cross-plow and seed with timothy or clover, which insures a crop of hay for the following year of from two to three tons per acre; after this it will produce three to five tons per acre from one cutting for many years, besides fall pasture of sufficient value to pay the expense of making the hay.

In a comparison of these lands with uplands for general farming, gardening, grazing, &c., there is almost as marked a contrast as between the prairies of Illinois or the valley of the Genesee and the arid sage plains of Colorado. The tide lands of the Pacific when reclaimed are unsurpassed in fertility and well adapted to all cereals, grasses, vegetables, and fruits belonging in this latitude and climate, and without doubt represent the greatest undeveloped agricultural wealth on these western shores. While in a state of nature these lands produce wild clover, red top, rye grass, bunch grass, and several other grasses of more or less value, but are too wet for general pasturage, except for cattle and hogs, and are of little value for hay on account of the difficulty in curing it. The tides at full and new moon usually flood the land.

Marshes can be reclaimed with profit anywhere on this coast, but farther inland along the Columbia and other large streams the expense would be much greater, in consequence of the annual freshets, which sometimes flood the inland marshes 6 to 10 feet deep for several weeks. Near the mouth of the Columbia, and along the bays and inlets on the coast, north and south, are hundreds of thousands of acres of these lands where there is nothing to contend with in diking but the tides. While many thousand acres of tide lands in this vicinity have been owned and occupied by the pioneers of Oregon for more than thirty years, very little has been done or attempted in the way of reclaiming them. Five years ago there were not 50 acres of reclaimed tide land on the Columbia River, and to-day there is less than 500 acres. Time and capital are requisite to insure success, and many are unable and some unwilling, to expend the necessary amount and wait for returns. To illustrate: A owns 200 acres, which he desires to reclaim; B owns the same amount, but has not the means to join A; C, with an adjoining tract, has no faith in the enterprise. These several parcels of land are so situated that the whole could be reclaimed almost as cheaply as one claim; but C refuses to sell, and we have no laws, either general, State, or local, under which he can be compelled to pay his portion of the expense, or even grant the right of way, for a dike across his premises. But the experiments of the past few years have settled the question of the practicability of diking, and demonstrated that these lands when reclaimed are nowhere surpassed in productiveness, and the result is that sleepers of a quarter of a century are waking up, companies are being formed, individuals are going to work, and before the birth of a new year (1885) several thousand acres will have been reclaimed in this county.

[Capt. Lewis G. Haavens.]

The tide land in my vicinity is adobe soil, with heavy fibers of tule roots (one-quarter of an inch diameter), to the depth of 3 feet. The soil resembles soap in being greasy and hard to wash away; hence little or no caving. The surface is from 6 inches to 1 foot above ordinary high water. The common rise and fall of water is 8 feet. The highest rise last winter was 3½ feet above the average level of the land, but this was by 8 inches the highest tide for seven years.

I made my ditch inside, to leave the outside banks solid to resist the water, but this cost in labor about one half more than to have ditches on both sides, as I intend in the future.

My dike is 10 feet wide at base, and 2 feet at top; average height, 4½ feet. I did not remove the turf, but intend to do so at the outside of the base to give the grass roots a chance to connect. I have not yet discovered any rats, or other animals, injuring the banks.

My first inclosure cost 23 cents per cubic yard (ditch inside), but I am confident that the work can be done for 15 cents. The only expense is the diking, as the tide lands here are naturally well drained.

Diked land is generally seeded with grass, with or without plowing; the tame grass killing the tules in a few years, providing the water is kept off. Reclaimed marshes are far superior to any other lands in this vicinity.

[A. H. Sales.]

The soil of my tide land is a rich loam of layers so distinctly marked that each year's deposit can be discerned. The surface is a rich vegetable mold. The soil extends downward from 7 to 10 feet to base of blue clay.

There are about 20,000 acres around and near the mouth of the Columbia River that could be reclaimed with profit.

The State claims marsh land under the Swamp Land Act, but it has not been withdrawn from sale at the General Land Office. This is the cause of some litigation and general dissatisfaction.

Though the attention of settlers has only lately been directed to diking, the marshes are being rapidly reclaimed. They are by far the most valuable lands we have.

[W. E. Dement.]

My land is within the Lewis and Clarke River, about 3 miles from Young's Bay, or from the mouth of the river. The soil seems to be a mixture of black soil (such as is on the surface of the high lands back), and yellow clay, and is of the same nature, 8 to 10 feet down. The tide lands near the mouth of this river, and on the Columbia, are of sand and clay.

Ordinary tides rise to the surface of the land, filling the sloughs and lowest spots; high tides go over the land, on an average, a foot deep; storm tides, once or twice a year, go about 2 feet above high tides.

Dikes are constructed of material from the marsh, but in some instances, for short distances, soil is taken from high land, or from other parts of marsh, on account of striking a spot of peat, which is liable to leak or wash. We take soil from both sides of dike to save expense of carrying; cutting ditch outside of dike here works no harm, from the fact of soil not washing; foot-prints remain for months where there is no sediment in water.

I inclosed 80 acres with 285 rods of dike. We fill sloughs with mud and brush—a layer of mud, then a layer of fine brush, starting at one side of slough and making just so much fill as we can keep up out of reach of the tide. If the water goes over the fill your work is washed out, but where you build up ahead of the tide there is no danger, the sides of the fill never washing.

As soon as the soil dries, say two months' good weather after diking, the ground is broken and oats sown; after that, anything suitable to tide lands can be sown. Here the wild grass, in some instances, is

either mowed and raked off or burned and timothy seed sown, without plowing, the result being one-third timothy the first, two-thirds the second, and pure timothy the third year.

The uplands do not compare with tide lands diked, in fertility. The tide lands produce double the weight of hay, or afford pasture all the year.

TILLAMOOK COUNTY.

[J. M. Alley.]

In Nehalem Valley is near 1,000 acres of alluvial marsh; elevation above low water, 6 feet; rise and fall of common tides, 6 feet; storm tides, 3 feet higher. Country, new; no marshes reclaimed. Settlers are dairymen, scarce of means, who take up only such lands as can be used with least expense. The Nehalem Valley is small, the land exceedingly rich, and climate mild. Above tide land the county is generally heavily timbered with spruce, hemlock, fir, cedar, alder, and smaller growth. The Nehalem River, with its two forks, its Bay and sloughs, affords fine facilities for rafting and booming logs. Two or three mill companies are trying to get the entrance to Nehalem Bay surveyed and buoyed, that they may establish extensive lumber mills. Access at present is very difficult. Coal exists, but its extent is not known.

[W. H. Fawcett.]

The vicinity of Tillamook Bay is sparsely settled. Farmers settle on the uplands, and take their claims so as to embrace portions of tide lands for grazing. First settlers were hunters; now with increasing immigration farming interests are looking up, together with the lumber and salmon industries. There is a large cannery on Tillamook Bay.

BENTON COUNTY.

[Allen Parker.]

Nothing of a permanent character done. Marshes could be reclaimed at small expense and would be very valuable. The little in cultivation produces wonderful crops.

LANE COUNTY.

[A. R. Butalph.]

There are no tide lands along the coast in Lane County; nothing but a sand beach or bluff rocks.

DOUGLAS COUNTY.

[Alfred W. Reed.]

About 2,500 acres on the Umpqua River; 6 feet above low water, and covered 3 to 4 feet by highest storm tides. Marshes valued at Government price—$1.25 per acre. I have had 40 acres diked this summer; others are waiting to see what success follows. In digging 2 to 3 feet I came to clay. Between the top earth and clay the ground was honeycombed by craw-fish. I had a ditch dug on each side of the dike over 3

feet deep to stop these holes. The craw-fish have come out in great numbers since we diked. I have between 300 and 400 acres more that I want to dike.

COOS COUNTY.

[County Commissioners.]

One thousand acres on Coos and Coquille Rivers; none diked, but the subject is under consideration.

CURRY COUNTY.

[N. C. Lorentzen.]

The tide land in this vicinity (Denmark) is not so much affected by the tide itself as by the damming of streams by the tides during summer; as a consequence, the lowlands are frequently put under 4 feet of water. When it has accumulated sufficiently it forces its way through the sand bank; and this operation is repeated again and again, until the rainy season enables the streams to keep open. When out of water, the tide lands are used for stock ranges.

WASHINGTON TERRITORY.

[W. Byron Daniels, Statistical Agent for the Department of Agriculture.]

The code of this Territory provides for the construction of ditches, drains, and water-courses in and through or along the boundaries of marsh lands.

Jurisdiction to fix and determine, and to open, construct, and regulate them, is conferred upon the boards of commissioners of the several counties. These laws, however, are crude, subject to constitutional and other objections, and should be superseded as soon as possible by more effective legislation, which will be practicably unattainable until such time as the Territory shall be admitted into the Union as a State.

COWLITZ COUNTY.

[Crumline La Du.]

The delta formed by the Cowlitz and Columbia Rivers is estimated to contain 3,000 acres. The general idea is that this body of land can only be protected by a levee extending from Freeport, on the Cowlitz River, to Oak Point Slough, on the Columbia, a distance of 16 miles. The United States Government and Northern Pacific Railroad own probably 1,000 acres of the lowest lands. The land is alluvial, similar in character to that formed by the Mississippi. Only an unusual tide overflows the lower lands, but they are submerged 4 feet by a medium flood, and in the high floods probably 10 feet. The reclamation would be a work of such magnitude as to be beyond any chance of being undertaken, except by Government aid. The current washes the banks away some on the Cowlitz River, while on the Columbia they are mainly damaged by the action of waves. If the land in question were reclaimed, the entire body would be worth, at a low estimate, $100 per acre. It is about 50 miles from Portland, Oregon, the chief market for this region.

WAHKIAKUM COUNTY.

[J. W. Clemens.]

Ten thousand acres tide marsh in county; nearly all Government land, and of little value at present. Covered with a dense growth of timber and brush; none diked; seems to be too porous, and being in small islands with large sloughs between, reclamation is considered impracticable.

KITSAP COUNTY.

[Puget Mill Company.]

Our reclaimed land is a rich river deposit, 12 feet deep. It is 8 feet above low water; would be overflowed at extreme high tide, if not for the dike; storm tides rise about 2 feet higher. Our dike is 8 feet at base, 2 feet on top, and 3 feet high. Turf outside, and soil from ditch thrown up against the turf. Not much trouble with muskrats, &c., only a few of these animals seen. The cost of constructing dikes, not including sluices, was about 25 cents per cubic yard, and of diking and draining marshes, $24 per acre. After reclaiming, we usually sow grain, and it will grow of its own accord. Crops on such lands are not subject to damage from drought as on uplands, and are very much better. There is plenty of land that might be reclaimed with profit, but no capital or inclination to improve it. Want of capital to make the dikes strong enough to stand the freshets has been the most common cause of failure. This is a very thinly settled country and yet in its infancy. People are flocking this way by hundreds, and they have come to stay.

WHATCOM COUNTY.

(Hon. J. S. Conner.)

Unimproved tide-lands well located, that is sheltered from heavy seas and yet close to navigation, are worth from $10 to $20 per acre. The lowest lands can be bought for $1 to $5. The highest of the above prices can only be got for the very best quality, close to this town (La Conner) where some of the largest tide-land farms in the Territory are located, having an abundance of the best improved machinery from the east, such as plows, harrows, sulky rakes, seeders, drills, mowers, reapers, self-binders, and farm steam engines. I have just diked 80 acres. I contracted with 2 laborers to dig a ditch 9 feet wide on top, 3½ feet deep, and 7½ feet wide at the bottom. The earth was thrown out by hand, forming a dike outside of the ditch nearly 9 feet wide at base, 3½ feet high, and about 4 feet wide on top, which is sufficient to turn the highest tides. These occur only from November to March 1st, and cover the marsh occasionally to a depth of 30 or 33 inches. At this season we have no crops in the ground, and in case of a break, which rarely occurs even with our slim dikes, many of which will not measure over 6 feet at the base, and 3 feet high, and have no width on the top, we would sustain but little damage. For building my dike, which is regarded as one of the best in this section, I paid $1.75 per rod, exclusive of the dams. For the land I paid $2,000, half cash, and half on one year's time, without interest, equal to about $1,850 cash. Its location being only about one-quarter of a mile from

this town, made it more desirable, and besides lands owned previously by me bounded it on two sides, leaving to be diked a distance of 213 rods. In that distance I crossed five sloughs, three of which were quite small, only costing from $10 to $30 each. The largest one cost $150, and the next in size about $60. In all that distance I have only 1 flood-gate, or box. My objection to numerous boxes is that they increase the trouble with muskrats, which are troublesome only at the boxes. Their habit is to cut a hole either beside the box or under it, and while our dams scarcely ever wash out here, even under a heavy pressure of water, still the muskrats manage to fill the ditches inside. I have finally adopted the plan of few boxes, and in putting those in I drive heavy sheet-iron 18 inches to 2 feet under the box, and 4 feet to 6 feet on each side and above it, up to the level of the marsh. As a last resort, when the muskrat cannot burrow under or beside the box, he will eat a hole in the door, which is usually of fir and 2 inches thick. I retained the largest slough for a reservoir, and cut a ditch 300 feet from it to the box. That ditch is 8 feet deep, and drains my field thoroughly.

The rise and fall of tides in deep sloughs is from 12 to 18 feet; here where the sloughs are shallow, the extremes do not exceed 12 feet.

With regard to cost and profit of this land, as compared with high lands, I think it fair to say that the cost of reclamation won't exceed one-third that of clearing the high land, and the profits are from two to three times greater. My land is all rented. I receive one-third of the oats in the sack, which gives me a rental of $7 to $10 per acre. Of course this will increase, as the county settles up, and labor (which is now $2.50 per day without board, or $1.85 to $2 with board) becomes cheaper. Ordinarily, we raise from 1¼ to 1½ tons of threshed oats to the acre. One of my neighbors last year raised 2 tons per acre. We can produce from 3 to 4 tons timothy hay per acre. No section of the United States excels this as a dairy country.

[Hon. Samuel Calhoun.]

Our reclaimed land is vegetable loam, from 2 to 3 feet deep, overlying a blue clay subsoil of 3 to 12 feet, and under that sand. This is varied with an occasional ridge, or spot of sand on the surface. These lands are about 18 feet above low water, and at the level of high water. The summer spring tides do not come above the marsh. The winter storm tides rise above the level of the land about 3 feet.

The dikes are nearly always constructed of material excavated from the marsh. Where the soil is of a peaty, vegetable or mucky nature, it is necessary to bring material from elsewhere. As a rule, most of the material should be taken from the inside of the dike, so as to have a good ditch to connect with the sluices, to carry off the seepage of the dike and drainage from the land. We seldom move the turf before constructing the dike; there are places, mostly along the creek banks, where the land is of such a porous nature that we dig a ditch, varying in depth as the occasion requires, then tamp it full with the same material, and build the dike on or over the ditch. The method most practiced here for building dikes, is to make a wall on each side with sods, grass side out, and fill in between with clay. The clay should be well tamped. Of course it will shrink and crack in drying, but when the cracks are once well tamped, there is no more trouble on that score. The base of the dike depends on the height; for a dike 3 feet high, we give 7 feet base; if 5 feet high, we give 9 feet base, with at least 3 feet across the top. Much dike is made here by simply throwing up earth or clay,

of sufficient width and height; this plan works well, but it takes more material to make the dike. We have no surf to contend with, being protected by a chain of islands.

We have different forms of sluice and tide-gates. For small creeks, where there is not much water, we take 4 planks, 3 by 12 inches, and spike or pin them together so as to have the top and bottom planks flush with the outside of the side planks, which makes an outlet 6 by 12 inches. The outer end of the sluice box is made with an incline of 1½ or 2 inches, so the tide-gate will fit well. The sluice box is cased around the outer end with planks about 8 feet long, running into the dam, (excepting the top planks, which are arranged so as to be taken off should the gate get out of repair) and projecting out by the end of the sluice box, to protect the gate from drift. The gate is made by framing a piece of plank 3 inches thick into a hard-wood roller, with 2-inch journals, which work in holes of corresponding size in the upper part of the casing. Gates made in this way should have sheet metal nailed on the surface, which adds weight, and so keeps the gate in place when the tide comes in, and also prevents muskrats cutting through. If the gate is hung at the bottom it will always be open when the tide is out, and the muskrats can pass in and out at pleasure, without being at the trouble of cutting a passage for themselves; then it needs no additional weight, the more readily it floats the better. At the outer end of the sluice there must be an apron to break the force of the water. All nails used in this kind of work should be of galvanized iron or composition; common iron nails rust out in a few years. Large sluices are made with two planks running through the dam 3 or 4 inches thick (4 is best), from 12 to 18 inches wide, as required, and planked across top and bottom with 2-inch planks. Often two or three sluices are made together, according to the amount of water to be let out. Where there is a great deal of water, more than the sluice-boxes above mentioned could discharge, we put in flumes. To prevent undermining of the flume, a bed should first be prepared for it. Select a place in the creek where the water has made a gully, and extend this gully, if necessary, to the length and width of the proposed flume. After placing a layer of straw on the sandy bottom (to prevent the sand running), fill the gully to the level of the bed of the creek; on this bed float a properly constructed flume, and weight it to its place with clay.

Muskrats have been somewhat troublesome, principally in dams, but if the dam is properly constructed there need be no trouble. Muskrats begin to burrow only where they can secrete themselves, generally in a gully or pool close to the dam, and always work up. To keep them out, crib up the sides a few feet from the bottom with logs, and drive a double row of stakes close together, besides filling with clay on each side of the apron a few feet from the dam, so as to leave no hiding places for them to commence work.

The cost per cubic yard of dikes, exclusive of sluices, is about 16 cents. The cost per acre for diking and draining marshes depends upon the area of land inclosed with one continuous line of dike. Here almost every one has diked his lands separately, from 40 to 160 acres in an inclosure. My opinion is that it has cost about $6 per acre, on an average, for the dikes alone. A ditch 3 feet wide and 3 feet deep costs about 20 cents per rod, and blind ditches about 50 cents per rod. For underdrains we use split cedar, placed in the bottom of the ditch, and cover with earth. Ditches from 15 to 20 rods apart afford good drainage, the land being porous.

The common method of treating diked lands here is to dig ditches to

tap the sags or depressions, fill in the small creeks or gullies, and plow the land as soon as it gets so solid that horses will not mire. We use here a 16-inch breaking plow with rolling cutter, which does excellent work, laying the soil over flat and smooth; with this plow we work three horses abreast, plowing on an average one and a half acres per day, 6 inches deep for the first plowing. We have had difficulty, the first two or three years, on account of the ground being soft in many places and bogging the horses. I have land that was so soft the first year or two that I could not go on it with teams, but since that I have plowed it with mules weighing from 1,200 to 1,400 pounds each without any difficulty. As the land is cultivated it settles and gets more solid; but as it settles it requires more ditches. After the land is pulverized we use the common stubble plow, two horses plowing from 2 to 3 acres per day.

The crops here suffer very little from drought. The year 1883 was exceptionally dry, without rain from the 1st of June to the end of September, yet the average yield per acre of oats (which is our principal grain crop) was about 60 bushels per acre. We consider the average crop of this locality 65 bushels per acre. An old field on these tide flats on which grain has been grown for seventeen successive years without any fertilizing, yielded, notwithstanding the drought, over 50 bushels per acre.

The lands compare very favorably with the uplands, the average yield being fully double in grain, meadow, pasture, and root crops; besides we have navigable creeks, where steamboats and schooners come and take the produce from our farms.

Timothy, red top, and clover are the only grasses cultivated here. Timothy yields 2½ to 5 tons of hay per acre, according to the condition of the meadow. Clover is cut twice a year, yielding over two tons per acre each cutting. The uplands are better for orchards and some of the small fruits, though plums, pears, and some varieties of apples do remarkably well on the flats. Potatoes do better on the uplands, though the early varieties do well on the flats.

The ebb and flow of the tide here on full tides is about 18 feet. Any marsh lying more than one-third below this height is too low to be profitably reclaimed. At one-third, by inclosing a large body—three or four hundred acres and upwards—it might be reclaimed with profit, even if considerably exposed to surf. Any land not costing over $40 per acre when reclaimed would be profitable. The low marshes are always firm, not being subject to peat or bog holes.

The diking of lands along navigable creeks has an unfavorable effect on navigation by diminishing the supply of water that carries off the sediment brought in by the flood-tides. It is only a question of time when this inconvenience will be felt.

This being a Territory, there are differences of opinion regarding the title to submerged lands. The most of this land has been surveyed and entered under the pre-emption and homestead laws, many of us having obtained Government patents to our lands. The Skagit River delta at its mouth is over 20 miles broad, and those owning the high lands could not possibly hold such a large tract of marsh land. There are several other rivers that empty into Puget Sound having similar deltas, but not to such an extent as the Skagit Delta.

There has been no perceptible depression during the twenty years that I have lived here, but there is every evidence of the ocean having encroached on this coast. Along the banks of one of the creeks that makes into this marsh, 5 feet below full tide, I find remains of Indian encampments in the form of burnt wood, ashes, clam and mussel shells,

stone axes, arrow-heads, and broken posts of houses. I find the same deposits from 2 to 3 feet above the level of the marsh, with large red cedar trees, which must be from two three hundred years old.

The reclamation of the land has had no perceptible effect upon the health of the neighborhood. The weather is never hot enough to cause malaria, the thermometer reaching 90 degrees not more than four or five days in the year. The nights are cool.

There are at least 50,000 acres in this county that might be reclaimed with great profit if there were organization and law to govern the same. This is a matter in which I have been long and seriously interested.

A bill was passed by our Territorial legislature in 1881, which gave general satisfaction. Four organizations were at once formed in this vicinity, and thousands of dollars were expended, but in enforcing assessments the court ruled the law unconstitutional, although it is the general opinion of the legal fraternity here that it was a consitutional law. Of course this put a stop to all improvements, and was a death-blow to one of the greatest industries of Western Washington. The law was as follows:

AN ACT to provide for the construction and maintenance of dikes and ditches.

Be it enacted by the legislative assembly of the Territory of Washington, That wherever there exists in one body, in this Territory, three hundred acres of more of tide, swamp, marsh, or overflown lands, owned and possessed by three or more persons, and when a two-thirds majority of said persons may desire to improve said body of land, or any part thereof, by the extension of dikes or ditches in, through, or around said land, two-thirds majority shall have the right and power to appoint commissioners for that purpose as herein provided.

SEC. 2. In order to appoint said commissioners for the purpose mentioned in section one of this act said two-thirds majority shall make and sign four written notices of their desire to improve land as aforesaid, describing in said notices the metes and bounds of the land to be diked or drained and the general nature and extent of the proposed improvement. Three of said notices must be posted in three conspicuous places on or in the vicinity of the land to be improved. The said notices shall also fix a time and place on or in vicinity of said land where a meeting of the owners of said land will be held to vote on the question of the proposed improvement and for the selection of the commissioners mentioned in the first section of this act, which meeting shall be held not less than ten days after the posting of said notices. The person posting said notices shall return the fourth to the meeting called thereunder, with his affidavit indorsed thereon or attached thereto showing the posting of said three notices, where posted, and the time of posting.

SEC. 3. The meeting called under said notices before proceeding to act shall select a president to preside over their deliberation, and a secretary. The secretary shall keep a record of the proceedings of the meeting, and he shall also record the notice returned in said record. The said notice returned, or the record thereof, shall be received in evidence in any proceeding under this act in all courts of this Territory.

SEC. 4. When the meeting has been organized as provided in section three, the president shall put it to vote whether the proposed improvement shall be made or not. The secretary shall keep a record of said vote showing the names of the persons voting for and against the improvement and the number of acres represented by each voter. The owner of the land to be improved shall be entitled to cast one vote for each acre to be improved. If a two-thirds vote is in favor of said improvement then it shall be made. The owner of the land may vote by agent as well as in his own proper person. If the vote is in favor of the improvements, the meeting shall at once in the same manner proceed to elect three commissioners to carry on, superintend, and make the proposed improvement, but a majority vote only in place of a two-thirds vote shall be necessary to elect said commissioners.

SEC. 5. The commissioners elected as aforesaid shall have power to cause to be established, located, and constructed the said proposed improvement, and shall have full supervision over the same. They shall locate said improvement in the best possible manner for the interest of the owners of the land affected by the location of the same. They shall estimate the amount of damages, if in their opinion the construction of said improvement will damage any owner of land more than the amount of benefits accruing to him by reason of the construction of the same, which should be paid to said owner. They shall assess the land benefited by said improvement for the cost and expenses of making the same, including therein the compensation to be paid to said commissioners and other officers created by this act and also the dam-

ages heretofore mentioned. The said assessment shall be made upon the land improved in proportion to the benefit which, in their judgment, the owner of said land will receive from the construction of said improvements. The sum assessed against said land by said commissioners shall be a lien upon the land improved to the extent of the sum assessed. The said lien may be enforced if the sum so assessed is not paid by the owner of said land, by a suit in the district court having jurisdiction in the county in which said land is situated. The said suit shall be brought in the name of said commissioners against said land and the owner, and the costs of said suit shall likewise be a lien upon said land. Before said assessment is made, the said commissioners shall notify all persons interested that on a day and at a place certain they will proceed to make and levy the assessment herein provided for. At said time and place any person interested may attend, and if he feels himself aggrieved by said assessment, he may appeal to the said district court in the same manner as an appeal is taken from an order made by the board of county commissioners. The notice of appeal may be served on the secretary of the commissioners or on the chairman of the board created by this act. The notice that the assessment will be made and levied, as in this section provided for, shall be given by posting three written notices on or in the vicinity of the land to be improved, which notices must be posted at least ten days before said assessment, and must be under the hand of the secretary of the commissioners.

SEC. 6. The commissioners created by this act shall at their first meeting appoint one of their number to act as chairman. At said meeting they shall also elect a secretary and treasurer. The secretary shall keep a record of all the proceedings of said commissioners. The chairman has power to call a meeting of the commissioners or of the owners of lands to be improved, in the manner provided in the rules and regulations of said commissioners. The commissioners, in case a vacancy occurs in their number by death, removal, or otherwise, may fill such vacancy. The commissioners shall receive for their services the compensation agreed upon by the owners of the land at any meeting held by said owners. The commissioners shall fix the compensation to be paid to the secretary and treasurer. The treasurer shall receive into his hands all moneys levied under this act, and shall pay out the same on the order of said commissioners. The commissioners may require the treasurer to execute a bond for the faithful discharge of his duties.

SEC. 7. On the first Saturday in June, in each year, after the first election of commissioners provided for in this act, a meeting of the owners of the land to be improved or being improved shall meet, and they may then elect other commissioners in place of those theretofore elected; the election to be held in the same manner as the first election for commissioners.

SEC. 8. The commissioners created by this act shall have power to make all needful rules and regulations necessary to carry out the provisions hereof. They shall have power, in case of danger from the breaking of dikes, to order out all male persons in the district of land under their charge, over the age of eighteen years and under sixty, to attend at the place of danger for the purpose of repairing such dike, in the same manner as the supervisor of roads orders out persons to work on the road in case of emergency; and if any person so ordered out refuses or neglects to attend, he shall be subject to a penalty of twenty dollars for each day he so refuses or neglects, to be recovered by an action in the name of said commissioners; and money so recovered shall be used in keeping said dike in repair. When ditches become obstructed they shall have like power to order out the persons aforesaid to remove said obstructions, under a like penalty; and money so recovered shall be used in keeping such ditch open.

SEC. 9. If any person shall dam or obstruct the passage of water in any ditch, or break or injure any dike constructed under the provisions of this act, the person so offending shall, on conviction therefor, be fined in any sum not exceeding one hundred dollars, as well as be liable to the persons injured by such wrongful act in the amount of damages sustained by reason thereof.

SEC. 10. The said commissioners, when they levy the assessment under this act, must cause to be made out by their secretary a roll, which he shall keep in his office, which roll must show the name of the owner of the land, number of acres improved, and the amount assessed against said land for said improvement. This roll shall be received in evidence in all the courts of this Territory. The said commissioners may divide the district of land to be improved by them into three or more subdistricts if they deem it proper so to do, and they may make one or more assessments to pay for making said improvements and paying the other expenses herein provided for. The commissioners also have power to make assessments for the repair of any dike or ditch constructed under this act, in the same manner, to the same extent, and with like effect as in originally constructing the same.

SEC. 11. This act shall not apply to incorporated cities or towns.

SEC. 12. This act shall not be construed so as to exempt the owners of land improved from paying county, road, school, Territorial, or other general tax thereon.

SEC. 13. This act to take effect and be enforced from and after its approval.

This law Roger S. Greene, chief justice of the Territory, declared unconstitutional, one reason being that assessment was according to benefit and not according to value. If the law is unconstitutional, the sooner the constitution is amended the better, if the marsh lands are to be reclaimed; otherwise, instead of making homes for families, they will fall into the hands of speculators.

This ruling has done an immense amount of harm to this section of country. One year ago last June, growing crops on two thousand acres in this neighborhood were overflowed and destroyed, bridges and dams carried away, and much other damage done. Since then organizations under the diking law have done much to prevent overflow from the Skagit. There being no commissioners to see to the repairing of these dikes and dams, should there be an unusually high June freshet, very great damage will be done. The jam at the mouth of the Skagit adds to the danger. There are, in all communities, dishonest men who will shirk, and without a law to compel scuh to do their part, the enterprising have to suffer. Chief-Justice Greene's decision is as follows:

On these demurrers the main question is as to the constitutionality of the act under which these assessments have confessedly been made.

Two things are manifest: (1) That this law undertakes to authorize the appropriation of private property for private improvements; and (2) that it undertakes to distribute the cost of any improvements according to the benefits and not according to values. Now, as to the second point, our supreme court, assuming that the sovereign power is capable of selecting the way in which the cost of an improvement made by public authority shall be distributed, says that for this Territory the United States exercising their paramount authority have prescribed a controlling rule by selecting and announcing values and excluding by their silence benefits as the basis of apportionment. This decision of the supreme court, being, of course, binding on this court, is decisive. It compels me to declare the statute void, because assessments under it are required to be in proportion to benefits and not to values. As to the first point, there can be no very serious question. Our entire political system, national and local, is a protest and a bulwark against the use of public power to accomplish private ends. Under it neither private property nor private faculty can be appropriated to private use against the owner's will. But this forbidden thing is the very thing which this disputed statute proposes to allow to be done. Improvements are contemplated without any reference whatever to public necessity, utility, or convenience. The statute does not make doings under it depend on public welfare, and it is therefore void.

But while I regard our present diking and ditching law entirely void, on the grounds stated, without specifying others, yet I may be permitted to say that probably there exist public reasons which would justify and sustain a fitly-devised and carefully-framed law. In the argument before me many points have been made resting upon the framework and phraseology of the statute.

Holding the views I do as to its constitutionality, it is unnecessary that I pass upon these points in detail or at all. I dismiss them with this general remark, that all rights wrung by a powerful majority from an unwilling minority are matters *strictissimi juris*, and are to be arrived at by an interpretation and construction of the statute giving them, strict as towards the majority, and liberal as towards the minority. Let the demurrers be sustained.

[R. E. Whitney.]

The tide lands of this country were taken by homestead and pre-emption settlers, who were mostly poor and unacquainted with the methods of reclamation used in other places. The dikes are built of the peat and clay of the marshes, and are from 8 to 12 feet wide at the base, 2 to 3 wide on the top, and stand, when settled, from 2½ to 4 feet high, according to location and length of purse of owner. Some claims are badly cut up with sloughs varying in width, where they have to be dammed, from 5 or 10 feet to 200, 300, and even 400 feet, and in depth from 3 to 15 feet. They are mostly dammed with dirt wheeled in from the banks, but in a few cases have been faced with lumber when exposed to the waves.

Some of the sluices, or drainage-boxes, are placed in the dam, and some in channels cut around the ends of the dam, so in case of a leak along or under the boxes the dams are not so much endangered. Self-acting hanging gates are generally used. Tides rise and fall 12 to 18 feet, so there is plenty of outlet for drainage. The dikes are built by hand, and the ditches are made on both sides, as a general thing, but some take the dirt only from the inside, which leaves a better ditch to drain the land. Cost of dikes, $1.50 to $3 per rod; cost of dikes and dams per acre, from $2.50 to $10. Several claims are sometimes united under one dike. Of course, the expense is less when many join together.

The land is not covered by ordinary tides during the summer months. In winter the tides run higher, and the undiked land is often covered from 1 to 2 feet deep, occasionally 2½ feet. Old settlers on the uplands tell of a tide, before these lands were diked, much higher than any of late.

Not much underdraining has been done. I began less than two years ago to put in split cedar underdrains. I cut the cedar 16 inches long, split it about 1¼ inches thick, and set the pieces in bottom of ditch, at an angle of 45°, leaning against side of ditch, throw in a little earth to hold in place, and then fill with plow. Have put in 2,500 rods and can see a great gain in dryness of land and increase of crop.

The land is very productive; oats, barley, and hay are the principal products. Oats yield from 50 to 120 bushels of 36 pounds, per acre, and barley nearly as much; hay from 2 to 5 tons per acre.

I have had $20, and over profit per acre on oats; but the average is not so high one year with another. Interest on money has been very high—12 to 24 per cent.—and wages high, so if the land had not been very productive and prices good farmers must have been ruined, as nearly all were heavily involved before they got returns. We think the land is worth at least double the value of the average upland.

Potatoes are not of good quality on the marsh, but nearly everything adapted to this climate does exceedingly well. Plums, apples, pears, and the small fruits, excepting cherries, flourish.

[E. A. Sisson.]

The land in this vicinity is a yellowish clay close to the sloughs, and a light peat farther back. As a general thing the peaty soil predominates. This top soil of peat or clay, as the case may be, is from 1 to 2½ feet in depth, and is underlaid by a stiff, bluish clay, which is from 1 to 4 feet in depth, and is underlaid by coarse sand, commonly called quicksand. The depth of the soil and clay increases with the distance from the highland.

The land lies about on a level with the average high tides, but the June tides rise about 10 inches higher than the land, and the winter tides from 1 to 2 feet.

Plain dike, exclusive of dams, costs from $2 to $2.50 per rod, or from 15 to 18 cents per cubic yard. All dikes here are measured or constructed by the rod. I don't think the average cost of the diking, that is, simply reclaiming the land from the salt water, has been over $8 per acre in this section, and some of it has been done at much less expense. The marshes are broken with a common breaking plow the following season after diking, and generally sown with oats, although wheat and barley do well. For growing paying grain and grass crops little else is needed after diking, except grading and filling the sloughs, which are all through the land. This grading probably costs from $3 to $5 per acre. Further draining, both open and covered, will pay well, and

owing to the nature of the soil can be done very cheaply, particularly in peat land, where it is most needed.

Marsh lands are not damaged by drought as soon as uplands. The past season, 1883, from June 1 until the crops were harvested, less than a third of an inch of water fell, yet the average yield of oats was above fifty bushels per acre, and in some cases reached eighty bushels. The hay crop averaged about three tons.

These lands are much more valuable for general farming than the uplands, and particularly for meadows and pastures. Apples, pears, plums, currants, gooseberries, raspberries, and strawberries (very fine) grow abundantly and profitably on our reclaimed lands; also most garden vegetables. Corn and tomatoes do not mature.

All grasses grow luxuriantly, but timothy and red-top are sown more than any others, and produce heavy crops of the finest hay. Blue grass and clover (red and white) also produce abundant crops.

Among the advantages of these lands for farming are rich soil, and large, smooth, level fields, which are free from roots, stones, stumps, and other obstructions to the use of machinery. Marsh land is free from sprouting timber and from fern, which is in all the uplands of this northwest coast; and the navigable sloughs render marketing a pleasure. Almost every farmer can have a steamer at his warehouse whenever he has anything to sell.

The disadvantages are few. The principal one is lack of fresh and good water, although it is thought that artesian water can be had. There is plenty of good rainwater most of the time if tanks are constructed to save it. Lack of timber and fire-wood has been called a disadvantage, but no part of the marsh is more than 2 miles from timber land, where it can be had in abundance. Exposure to the winter winds might be called a disadvantage; also lack of good roads in the winter season. These are impassable without planking.

It is my opinion that any marsh which lies as high as the average high tide of the summer season, and that is 6 feet above low tide, and covered with natural vegetation, can be reclaimed with profit, providing it is not exposed to the surf of a large body of water.

Very little use has been made of the natural vegetation of salt marshes in this country, except for grazing, and it is of little value for that purpose, except where the marshes are frequently overflowed by fresh water.

[Perry Polsen.]

The tide lands in this vicinity are black vegetable mold, from 3 inches to 3 feet deep, underlaid with 6 to 10 feet of a bluish mixture of sand and clay, which becomes very hard when dried in the sun, but when frozen is easily pulverized. Under this is sand.

Generally it is best that the ditch should be dug inside, so as to carry the seepage water to some slough or other reservoir. Only where the sand is very near the surface is there any danger in cutting a deep ditch inside.

Three feet base for every foot in height is a good rule in building dikes. It is not necessary to remove the turf before building.

Red and Alsike clovers do well, as does also timothy. Five tons of hay per acre, clover and timothy mixed, have been cut from one acre in very many instances.

Where the actual cost of reclaiming does not exceed $35 per acre it will pay on Puget Sound.

The want of a law to compel each land owner to do his share toward diking and ditching is the chief hindrance to greater improvement.

APPENDIX No. 1.

RECLAMATION IN NEW JERSEY, ENGLAND, AND HOLLAND.

[Report of the State Geologist of New Jersey, 1869.]

This work of banking in meadows has gone forward till the territory rescued from the sea amounts to 15,000 acres in Salem County alone, besides large areas in Gloucester, Cumberland, and Cape May counties. The largest tracts, and perhaps the most successfully managed, are in Salem County. The work has all been done by private enterprises, the owners of a tract that could be profitably inclosed by a single bank, associating themselves together, and carrying the work forward under the terms of the banked-meadow law.

Nearly all banks require occasional additions to the top caused by crumbling of mud, or more frequently by the settling of the whole bank. Where they are built upon firm mud, as is commonly the case along streams, the amount of settling is very little, but where they cross a meadow, or form what is called a cross-bank, or run across an old water-course, the settling is an item of much labor and expense. Some have sunk 10 feet in the same number of years. The cross-banks are more liable to settle because of the thinness of firm mud covering the peaty mass beneath. Wherever built upon such peaty substratum settling is inevitable, and continues until a solid bottom is reached. The settling is generally gradual, but instances are given in which the bank has gone down at once out of sight. As long as tide marshes are open, liable to be overflowed at high water, and so kept soaked full, they remain nearly at the level of high tide, but after banking and draining they become quite dry, and the spongy mass slowly decays and is consolidated, thereby causing a sinking of the whole surface. Tillage hastens this subsidence by opening the mass to the action of atmospheric agencies, and by a large annual withdrawal in the form of crops. From these causes a slow and gradual settling is effected. In nearly all banked meadows the difference in heights of the outside guard and the inclosed meadow is very perceptible. The constant silting of fine sediment upon the areas outside the banks often brings them nearly up to the height of the projecting bank. And after a long series of years of cropping, the meadow settles down to low-water mark and it becomes unprofitable for further cultivation on account of imperfect drainage. To remedy this the banks are opened at several points and the muddy water allowed to enter and deposit its sediment upon the surface. The thickness of this deposit varies exceedingly, some streams depositing much more than others in the same time. Maurice River and Salem Creek carry down a large amount of mud, while Alloways Creek deposits a mere film on the surface in one season. The meadows are left open to tide-water for a period of from five to ten

years, according to the rapidity of deposit. A meadow near the city of Salem which has been open to the tide for ten years has now a mud deposit covering it to an average depth of 2 feet. By this covering of mud the meadows are raised so as to be drained with more ease, and their quality is much improved; the grasses also are much more nutritious. This operation really covers the meadow with a new soil and one of lasting fertility. Some meadows settle so little that they have been tilled regularly for the last seventy years, and it is said that on some the banks have been in repair for over a century. These are exceptional cases, however. To open the banks requires the consent of the owners of three-fourths of the included acres.

Another mode of counteracting the settling and also of improving the meadow, is to allow the tides to enter during the winter by opening the sluices. In this way a layer of muddy sediment is deposited all over the surface, which may vary from a mere film to 12 inches in thickness in one winter. The best and most practical meadow managers prefer this winter flooding.

These meadows are composed of earthy or vegetable matter, all of which has the common designation of mud. Blue and gray mud is a deposit of clayey substance, and is blue when wet and gray when dry and weathered. Black mud is fine muck, or disintegrated vegetable matter. Horse-dung mud or turf is the fibrous and peaty matter that constitutes the spongy part of the marsh, and is nothing but a network of grass and sedge roots. In most of the meadows the blue mud rests upon the peaty mud. The gray mud is most abundant near the banks of streams. It would seem as if the blue and gray mud deposits of this region are of recent origin—as late as the settlement of the country and clearing of the forests. Streams now hold in suspension a much greater amount of mud than when the country was covered with woods.

The banked meadows of Salem and Cumberland are the very best of grazing lands, and furnish indirectly a vast amount of manure for the uplands. The lowest of them grow herds grass, which is raised for seed. Salem is the great center of the trade in this product for our whole country. The average yield is about 30 bushels to the acre, and a common price for it is 75 cents a bushel. The stalks, though not as good as hay, are valuable for fodder and litter. The care and expense of such lands is but very little, so that the crop may be considered a profitable one. The meadows along Maurice River are found suitable for the growth of timothy and grain and root crops, and enormous crops of these are grown from year to year without any manure. At Finn's Point the yield of wheat is from 30 to 40 bushels per acre, and of potatoes from 150 to 200 bushels. The blue and gray mud soils are always good for any crop whatever. The black mud is not reliable for wheat, but Indian corn thrives on it. Lime acts like a charm on meadow everywhere. It is common to use it in dressings of 100 bushels an acre, with good effect.

The value of the banked meadows in Salem may average $100 an acre, some being worth $400 or $500, and others considerably less. On the Cohansey and Maurice Rivers they are much more valuable than the adjoining uplands, ranging in price from $50 to $200 an acre. Before they were banked these marshes were almost worthless. They yielded at the best salt grass or sedge, which may be used as a coarse fodder or for packing. In Lower Alloways Creek, Salem County, salt marsh bordering the Delaware is worth from $1 to $5 an acre. About Leesburg, Cumberland County, it sells for from $10 to $20 an acre.

The common opinion among meadow men is that all marsh which can be made to grow herds grass can be profitably banked where the cost of banking does not exceed $15 an acre. In short, all meadow or salt marsh that can be drained by open ditches may be reclaimed with profit, and if it is 2 feet above low-water mark that is generally practicable. Where water is quite salt, as is the case near the ocean or mouth of the bay, the meadow will need two or three years to get freshened enough to grow anything except salt grass. Time will, however, in nearly all cases after banking, bring about such a change that herd's-grass may be raised, if not timothy and the clovers. The great point is to get drainage; the tides can be shut out, no matter how high they rise. The question then is, how much is the marsh surface above low water? and if not too low, banking is both practicable and profitable.

The following is a tabular statement by counties of the number of acres of tide meadows fresh and salt in the State:

Counties.	Acres.	Counties.	Acres.
Bergen	11,910	Cape May	58,824
Hudson	12,896	Cumberland	51,078
Essex	4,282	Salem	28,602
Union	4,445	Gloucester	9,958
Middlesex	7,335	Camden	3,652
Monmouth	5,958	Mercer	1,946
Ocean	31,155		
Burlington	25,429	Total	295,474
Atlantic	38,003		

Of this great extent of marsh, only about 20,000 acres are inclosed by dikes, nearly all of which is along Delaware river and bay. The remaining 270.000 acres are still comparatively unimproved, and worthless for real agricultural purposes.

[From the Report of the State Geologist of New Jersey, 1870.]

In England the largest drainage works are in what is called the Fen country. This is an extensive tract of wet, swampy, and marshy land lying on the east coast, beginning about 80 miles north of London, in the counties of Norfolk, Cambridge, and Lincoln, and near the mouths of the rivers Ouse, Nene, Witham, and others. There are a number of tracts along the east coast and some of large extent, but they all have the same character and their management is similar. The drainage of the Fen country about the Nene and Ouse was first undertaken by the Duke of Bedford, and hence is known as the Bedford Level. It comprises about 300,000 acres. Much of this land lies below high-water level, and so was liable to the overflow of the tides; but its greatest damage was from floods in the rivers which pursue their crooked and sluggish courses through it. These streams carried the drainage water from as much as 5,000 square miles of the higher country, and in heavy rains or in wet seasons they overflowed their banks and laid the whole of this flat country under water. In dry seasons some of the land could be cultivated and summer crops secured, but in wet seasons all crops were destroyed. From the earliest periods of English history attempts were made to prevent the damaging effects of these overflows, but for a long time with only indifferent success. The leading features of the plan pursued by the Earl and Duke of Bedford in their works between 1630 and 1653 were to convey the upland waters through the level to the sea by means of straightened and embanked rivers, and to

prevent the tide from entering and overflowing any portion of the level. The level was divided into three parts, the north level containing 40,000 acres, the middle level 140,000 acres, and the south level 120,000 acres. Each level was defended by high barrier banks.

Another feature in his scheme was to cut large new straight drains within each level to carry the ordinary rainfall to the rivers, into which they could be discharged by sluices.

The two great defects of this plan were, first, the omission to provide for the improvement of the natural outlets to sea at Lynn and Nisbeach. It went no further than getting the water out of the Fens into the drains and rivers running through the level, and gave no attention to the discharge therefrom, whereas its first great work should have been to secure for these drains and rivers the best outlet possible to sea, for without that all internal works, however good, must eventually fail. The second defect was in not making the new drains and cuts of sufficient depth. They did not understand or properly consider the nature of the soil to be excavated. This soil was a deep bed of peaty earth which had been growing and accumulating for centuries, and for drains to be permanently efficient it was necessary that this bed should be cut quite through to the natural soil on which it rested. This was not done, and the consequence was the peat bottoms of the drains began slowly to rise up towards the surface of the water, and so to impair and finally ruin them. While this was going on a process of a directly opposite character was going on in the drained lands around. While one was rising the other was subsiding. This soon made it necessary to provide other means for passing the drainage water from the lands into rivers and large drains. Associations of neighboring farmers were formed for more effectually draining small districts, and these associations partially attained their objects by erecting scoop-wheels for lifting the water and windmills to drive them. These were in a measure successful, but not to the degree that was needed. In 1821, after years of opposition, a deep cut was made to shorten the course of the river Ouse near Lynn. At this place the river took a bend almost at right angles to its general course for a length of 5½ miles, forming almost a semi-circle, while the diameter joining its two ends was only 2¾ miles across. The substitution of this straight cut for the former long and tortuous one was attended with most remarkable and beneficial results. The Ouse, at the upper end of the cut, had its low-water line reduced 7½ feet, and there was a corresponding lowering of the water surface in all the connecting drains. Various internal improvements were carried out at the same time to secure the full benefit of this lower outlet, and steam was substituted for the irregular and uncertain force of wind.

Since then an estuary cut for 2 miles below Lynn has still further straightened the outlet of the Ouse to the sea, and has caused a depression of the low-water mark at Lynn of from 3 to 4 feet, and has given a greatly increased efficiency to drainage by sluices. It has also diminished the lift for the water which has to be raised from the ditches into the drains and rivers. The system of works necessary to keep up this drainage has been planned by some of the best English engineers, and the constant attention of several professional engineers is now required to keep the various parts in working order and to make such new erections or changes as are needed. But it is a marvelous success, and the country which was formerly a worthless marsh is now the most productive land in England.

To Mr. Alfred S. Ruston, of Chatteris, England, I am indebted for

many particulars relating to the Fens. He went with me to examine various farms, to explain their modes of culture and the system of drainage which is now in operation. He gave me all the particulars I could ask for in full detail, and I cannot do better than use his own words in presenting them:

"If fen lands are to be perfectly and successfully drained, the true principle is first of all to secure the best possible outfall for the discharge of the waters, and then to construct the internal works of corresponding dimensions and depths, giving where practicable a natural drainage, and where not, reducing the pumping power to a minimum; and sooner or later I conceive this will be the principle adopted by all the drainage levels in the kingdom.

"One important and somewhat startling fact in connection with the review of the drainage history of the great level during the last two or three centuries, strikes one, and that is, that all the great works which have contributed to drain the land effectually, rescuing it from all risk of winter floods, and making it really valuable, have been made during the present century. At the beginning of the century the lands were little more than summer lands, and men were considered demented who ventured to sow a whole field with wheat. But now the fens are the great corn-producing lands of the kingdom, and have been not inaptly termed 'the granary of England.'

"The subsidences of fen lands after they become drained is a subject deserving attention. The more we drain the lower our lands become, and we are beginning to inquire what is to be the end of all this. I am informed by Mr. Lawrence, the agent to Mr. Wells, that when Whittlesea Mere was drained, to ascertain accurately what the subsidence was, a Doric column was placed in the ground, on which feet and inches were marked downward from the capital, which was the original surface of the land. That surface is now 7 feet below what it was when they began to drain the mere eighteen years ago; and in the middle level on all our old drained lands, we find the subsidence is still going on at the rate of an inch per year. We learn this from our drainage engines, which are continually requiring the centers of their water-wheels to be lowered, or the ladles to be lengthened, or they would lose their dip altogether. The increased facilities of discharge through the improved outfalls must continue to be felt until the peaty subsoil shall well nigh disappear. One of Lord Orford's companions on referring to their passage through Salter's Lode Sluice, tells us that the tide rises at that place 5 or 6 feet. On the 21st of February of the present year, it rose to 22 feet 3 inches at 11.15 p. m. The effects upon drainage of this altered state of things, and consequently upon subsidence, must be obvious to every one.

"The Fen rivers and drains, so useful and essential for the discharge of the flood waters of winter, are scarcely less valuable for the supply of fresh water in the summer. It is not easy to overestimate the immense value of a good and a liberal supply of fresh water for the whole Fen country during the dry summer months, and I need hardly say every effort is made to obtain this. The practice of irrigation has not found much favor in the Fens, and it is questionable whether it would be of any great good where the waters possess so few fertilizing elements. Irrigation appears to depend for its success very much upon the chemical substance contained in the waters. An analysis of the water will pretty correctly indicate what will be the effects of its overflow. Cultivation and drainage have gone on hand in hand, each successive improvement in the one leading to a corresponding improvement

in the other. During the early drainage history most of the low-lying Fen lands were kept in grass, as they could not be profitably brought under cultivation in consequence of their liability to inundations during every recurring flood. Some farmers ventured to sow a few oats on the higher lands, but it was not until May was well in and the winter rainfalls had passed away to sea. By and by oats were grown more largely, and wheat was cultivated to some extent.

"Then came the system which prevailed very generally in the Fens for a good number of years, and which was to let the land keep in grass for two or three years, then pare and burn and sow with cole seed to feed with sheep during the winter months, to be followed by oats, and then wheat, and again sown down with seeds to remain two or three years, often three. This virgin soil, under such management, produced coleseed of most extraordinary fattening qualities, and perhaps there has never been any natural food that would compare with it or that would in so short a time produce so much weight of mutton. It was otherwise with the seeds, for after the first year they contained comparatively little nutritive properties, and their long continuance on the land made a fine refuge and breeding ground for the wireworms, to which the succeeding crops ofttimes bore indubitable testimony, and to this day they remain the greatest foe the Fen farmer has, and it is a very unusual year when his oat crop is not more or less ravaged by them. Probably the greatest improvement next to drainage and consequent upon it is the practice of claying fen lands. The value of clay, I believe, was first accidentally discovered by some of it which had been thrown from the ditches having been spread round the outsides of the field and which produced most marvellous effects upon the growing corn crops.

"Our fathers were not slow to learn, and were very soon led to adopt a system of claying which still continues, some lands having been gone over three or four times. The plan is this: pits or trenches are made down the fields, from 2½ to 3 feet wide, and from 12 to 16 yards apart; two spits of clay are taken therefrom, and spread upon the intervening land, the peat or clunch subsoil being thrown to the bottom of the trench, and when all is finished, the pits are plowed in, and the land being loose, and easily moved, is soon leveled again. The cost of claying is governed by the depth at which the clay is found from the surface of the land, but improved drainage occasioning a continual subsidence, as I have already observed, is bringing it within easy reach, and thousands of acres can now be done at a cost of thirty shillings per acre, and under; and no money expended on a Fen farm yields so quick and so bountiful a return. The application of clay to these light soils not only gives solidity, but being possessed of considerable fertilizing properties, greatly enriches them. Happily the Fen lands very largely rest upon a clay bed; but the clay is not of a uniform quality. That which is blue and of a soft buttery nature, contains the most lime, and is the best fertilizer. Some is silty and some stony and hard, and these do little more than solidify. Perhaps the next great improvement consequent upon the drainage of Fen lands is their deep cultivation, to which reference has already been made. To talk of turning over a furrow slice 30 inches in thickness must sound to a clay-land farmer something like a piece of exaggerated nonsense; and may put his credulity to the test, but it is no exaggeration. Deep cultivation on Fen land is generally accomplishe dby horse-power, as the great underground forest offers considerable obstacle to the application of steam. A pair of horses in a common plow go first, and take a furrow 4 or 5 inches thick, and are followed by a huge implement made expressly for the purpose, and

which is pulled by six, eight, or ten horses as the case may be. This plow buries the furrow turned over by the small plow, and brings the subsoil well onto the top, that its vegetable properties, by exposure to the atmosphere, may become speedily decomposed and made available as food for plants. One object in putting the top furrow down is to get it as far as possible beyond the reach of atmospheric influences, with the idea that under these circumstances the twitch or couch and weed roots will die and decay. It certainly is a very clever and ingenious way of cleaning land, if it can only be done; but my experience and observation lead me to the conclusion that it far oftener fails than succeeds. I think land should be quite clean before it is deep plowed. There can be no doubt but deep cultivation tends to preserve moisture in the soil in dry seasons, and to facilitate drainage in wet ones. It also unlocks those hidden treasures in which are so many elements of fertility, and consequently increases the producing power of the land. Drainage, clay, and deep tillage, to which should be added superphosphate of lime and the water drill, have completely metamorphosed the country and altogether changed its modes of husbandry; and perhaps there is now no country so utterly defiant of system. Although there is no uniformity of system in the cultivation of Fen lands, there is, however, a five-course shift which has found favor and which prevails more largely than any other, and to which several farmers pretty strictly adhere. This is the order of it: mangolds, kohl rabi, cole-seed or cabbages which are gradually growing into favor; oats, wheat, seeds, wheat. The green crops and the oats are sown with artificial manure, the farm-yard manure being reserved for the wheat crops. This rotation appears well suited to the Fens, and has been pursued with considerable success; but as I have intimated, Fen farmers break away from the restraints of system to follow their own inclinations. A ride through the Fen country at the proper season will show the truth of this. In addition to the crops usually found on a farm will be seen cole-seed, turnips, linseed, mustard, and cress, growing as seed crops, and potatoes and carrots extensively cultivated for the London and other large markets. Turnips are not at all suited to Fen soils. They grow of a woody, fibrous quality, coarse and long in the neck, and possessing scarcely any nutriment; they are almost valueless as food for stock, and are consequently not cultivated.

"Kohl rabi and mangolds are much better, but these, like the hay, straw, and other products of fen lands (cole-seed excepted), are very deficient in fattening properties. I have already referred to the water drill and superphosphate of lime, and their value in the successful cultivation of fen lands. Our fen soils appear to yield much larger supplies of ammonia than phosphates; hence the free application of phosphatic manures is accompanied by much greater and more palpable results than is the case where ammoniacal manures are used. Probably there is no part of the Kingdom where the application of phosphates to the soil has produced such startling results, and especially where they have been applied with the water drill. The Fens have not been especially famed for the breeding of either cattle or sheep, but from very early times they have been noted for their good breed of cart-horses. The decreased average of grass seeds, consequent upon the increased average of corn and other crops, has largely tended to diminish the number of animals bred; but the show of cart-colts, both as regards number and quality, on the first of July of every year, is pretty good evidence that fen farmers have not altogether lost their long-enjoyed and well-merited reputation.

"The Great Level generally, even now, under its more perfect drainage and improved cultivation, offers very few tempting residential inducements, and formerly, under other and more unfavorable circumstances, it repelled rather than invited residence. Hence it is not uncommon, in many parts of the Fens, to find both farmer and laborer residing in the town or village, rather than upon the farm.

"The value of fen lands has increased or decreased just as the drainage has been efficient or otherwise. In 1651 Lord Arundel, one of the Earl of Bedford's associates, in draining the Great Level, became so discouraged by the reverses and losses sustained by the adventurers that he sold his share for 3*s.* 9*d.* per acre, the same land now being worth probably from £30 to £50 per acre. Many farms in later times have been sold at very little over their present annual rentals, and some at even less. Through the kindness of Mr. Richards Trimblington, I am able to present the assessments to the poor rates of certain lands in the parish of Doddington, made at different periods, showing the influence which improved drainage has had upon the value of fen lands:

Year.	Acres.	Ratable value.			Year.	Acres.	Ratable value.		
		£	*s.*	*d.*			£	*s.*	*d.*
1736	200	40	0	0	1833	60	21	0	0
1784	200	60	0	0	1869	60	68	1	4
1822	200	100	0	0	1757	20	2	0	0
1869	200	238	0	3	1784	20	5	0	0
1784	60	15	0	0	1869	20	26	0	0

The above statement has been written by Mr. Ruston since I enjoyed the benefit of his explanation on the ground, and he has favored me with the printed copy. His residence is in what are called the Black Fens, the soil being black with muck and decaying vegetable matter for a depth of from 2 to 10 feet. The clay of which Mr. Ruston speaks is the earth under the peat, and is quite calcareous. There are portions of the fens nearer the western border—for example, near Peterborough—and the Whittlesea Mere, where the whole substance is black and more like turf. Such cannot be cultivated until they are burned over, so as to get an accumulation of ashes, or else are covered with earth brought from the upland, or from pits sunk through the peat down to the solid ground. Pits are sunk through the turf 9 feet deep in some places to raise the bottom earth to the surface, and the land is dressed with it at a cost of from $12 to $18 an acre. I saw good crops of grain, cabbage, and turnips growing on ground prepared in this way. The fens containing turf are, however, the most expensive and difficult to reclaim, and there are considerable tracts which have not yet been cultivated.

The parts of the fens nearest the sea shore or on the river banks are the best. The soil contains a large proportion of sand and clay sediments, and is not liable to settle, and it needs no claying. It has been filled up by the deposits from muddy water and the wash from the river floods. It is the very best and most productive of all these reclaimed lands.

The banks which are built to confine the streams and hinder them from overflowing the country on their way to the sea, as well as those along the seashore, are of the most substantial kind. They are constructed after the plans of engineers, and built under their directions. Generally they do not differ from the banks of canals or other structures which are required to resist the pressure of water. From the

nature of the fen soil—the layers of peat, sand, and mud in it—great care is necessary in preparing the foundations of the banks. Those which are built now are usually 6 feet wide on the top, and built with a slope of two base to one rise; and to keep them firm they have a foreshore of from 6 to 14 feet, and the middle of the bank is puddled with clay. This puddling is done by digging a trench 3 feet wide along the middle of the foundation, and sinking it down to the solid bottom. The trench is then carefully puddled with clay to the surface, and up as far as the nature of the materials in the bank require, in order to make them water-tight. Like all other works of this kind there have been numerous and expensive failures in the banks from lack of good foundations. In 1862 a most extraordinary accident took place, from the undermining of the sluice-gates of the main drain of the Middle Level at its confluence with the river Ouse. This drain has to carry an immense quantity of water. Its bottom is 7 feet below low-water mark, and 48 feet wide. Its sides have a slope of two base to one rise, and spring tides there have a rise of 19 feet, so that its width at the high water line is 152 feet. The sluice-gates were like canal lock-gates, and in three pairs of 13 feet each, thus making a clear water-way of 78 feet. The water in this drain runs out through the sluices during low water, until it almost comes to low-water mark. From some imperfection in the foundation these sluice-gates gave way and the tide-waters were let into the drain. They rushed up and again poured out of the drain with great velocity, and throughout a distance of 20 miles they ebbed and flowed. This state of things continued for several days, when one of the banks of the drain burst, and let the water in upon this low, but rich and cultivated country, and completely inundated 6,000 acres of land. The damage done by the flooding was enormous.

The method resorted to for again stopping the drain is very curious, and may be worth the description. With great pains and at a large expense a solid, strong dam was built across the drain so as to completely shut out the tide, and then sixteen siphons, each 3½ feet in diameter, were laid so as to draw the water out of the drain above the dam, carry it directly over the top, and discharge it into the drain below. The siphons are set in operation by means of a steam engine and air-pump, and they are guarded by valves so that they may not carry water up stream during the flow of the tide. They have now been in operation eight years, and have answered their purpose completely. The water in the drain flows up to the dam with a strong current, runs over it in the siphons, and then, a great river of water, it runs off in a rapid current towards the sea.

Some of the oldest of the banks are still settling, with the long continued drainage of that country, and every year they have to make repairs, at large expense, of cracked and settled banks.

When the water in the streams is high the drains cannot discharge all the water that falls on the fens into them; and with the continued settling of the soil the sluices come to be more and more incapable of discharging all the water. When the drainage was first completed wind-mills were used to pump the water from the ditches into the drains, but they were too uncertain in their action. When the water was abundant and there was no wind the lands would be overflowed, and now steam-engines have almost entirely taken the place of the old wind-mills for driving the pumps. There were formerly as many as 700 on the fens between Lincoln and Cambridge. A few are still left, but the

place of most of them is taken by about 60 steam-engines, which range from 10 to 80 horse-power.

The water is chiefly raised by scoop wheels, and not by pumps. These wheels are almost like the paddle-wheels of a steamboat, and they are set so as to fit closely, but without touching, between parallel stone walls, and the bottom is curved upwards in front. When the wheel turns it presses the water forward in the narrow passage and upward till it is raised sufficiently to run over into the drain. Such wheels will lift economically to a height equal to one-third their diameter. The height to which the water has to be lifted varies in different localities. From 2 to 10 feet are common cases.

Some very large rotary pumps have recently been erected for the drainage works near Boston, in Lincolnshire, and it is claimed by the ablest engineers that they are cheaper to work and more efficient than the scoop wheels.

The amount of water raised is enormous. At one place in the Deeping Fen the engines raised 300 tons a minute to an average height of 7 feet, and the whole fen of 25,000 acres is drained by two engines of 60 and 80 horse-power.

The way of determining the power needed for any drainage is to take the greatest rainfall in any month, make the proper allowance for evaporation, and then calculate the number of cubic feet of water that will remain on the whole number of acres to be drained. Then allow that the engines can be kept at work 25 days in a month and 20 hours each day, which is 500 hours a month. Then provide an engine and pump which are capable of doing the work, and the plan is completed.

The machinery and power necessary to drain these lands is now well understood and is put in operation. The water is kept in the ditches at a level which is from 2 to 3 feet below the surface of the ground, varying somewhat with the crops that are to be grown. It is found that the presence of the water within that distance from the surface is favorable for the growing crop and a security against drought. The last summer was one of unexampled dryness, and the fen farmers found it was very useful to them to have water in the ditches, and great care was taken not to let the water out below a certain level, but, on the contrary, to dam it back so as to hold it up to the proper height.

Mr. Ruston informed me that a portion of the fen near Chateris, in which he is interested, contains 10,000 acres, besides 2,000 acres of upland, and it is drained by an 80-horse power engine, at a cost of 6 pence an acre per year. This is the cost for the year, but it is not by any means the annual tax, as, additional to the expenses of the year, there are large debts which have been contracted and must be paid; also parliamentary and other expenses. The tax in 1870 was 1*s.* 9*d.* an acre on most of the land and 10½*d.* on the rest. The heaviest taxes that can be imposed upon these lands are 3*s.* 6*d.* and 1*s.* 9*d.* an acre. The taxes in some other parts of the fens are a little higher, being from 4*s.* to 6*s.* an acre.

The first cost of these improvements has been enormous—95,000 acres out of 300,000 were given to the first Earl of Bedford for making the drains and connected works—and there are many districts in this great level where farmers have combined to make additional improvements at their own costs. It is said that there are more than a hundred acts of Parliament relating to the fen drainage. The parliamentary expenses are very large, as every bill is strongly opposed and must be fought through. The Middle Level has a debt of £500,000, and arrangements have to be made for paying it off within twenty years of the time

it was contracted. The expense of the siphons in the Middle Level drain were £62,000. Other sums of money equally large are spoken of in connection with different parts of the fens, but it is found by experience that they are small when compared with the value of the land or its extraordinary fertility. It bears all these expenses and continues to increase in its power of yielding productive crops and supplying food to the rest of the kingdom.

The Netherlands have long been noted for the great extent of land liable to overflow. The country itself is very flat and low, and has no ranges of hills to break the uniformity of its surface. It is open to the North Sea along its north and west borders, and on the south is crossed by the Rhine, which brings down an immense volume of water from the hilly and mountainous parts of Western Germany. In North and South Holland there is a border of sand-hills, dunes, or, as we should call them, beaches, along the sea, but the more southern provinces have no such protection, and are exposed to the direct action of the waves. In both, however, the country is liable to be overrun by the sea, the only difference being that the water naturally runs off quickly in the southern provinces, while in the northern the dunes hold it back, and so favor the growth of turf and the accumulation of muck. Along the Rhine the country is equally exposed, and when great floods occur in that river, and the water comes down to the flat country where its current is checked, it overflows its banks, covering the whole country and causing frightful damage to life and property.

In dry seasons some of the ground could be cultivated or pastured, and so support human life. But the dangers to which they were exposed obliged them to maintain a constant struggle with the floods, and the history of the country is full of accounts of the making of dikes and their failures. At first the dikes were made of reeds and grass; later, of logs and beams of wood; more recently, of earth, and in exposed parts they are faced with stone, brush, straw, and grass. The kingdom has an area of about 12,000 square miles, and full one-half of it is so low as to need protection from the water. Heavy banks or dikes are built along the shore of the sea and the borders of the rivers to keep out these floods. The leakage water and the rainfall were drawn off from the higher portions of this land by means of tide-sluices, which opened so as to allow the water to run out at low tide, and closed to hinder any from running in at high water. The larger portion, however, was too low for this mode of drainage, and rain and leakage waters had to be raised by pumps. In some localities the water has to be raised only 1 or 2 feet; in others, 10, 15, 20, and, in a few places, even 22 feet, before it will run off into the rivers or sea.

The magnitude and importance of these works can hardly be estimated. The oversight and management of them is intrusted to one department of the Government, the Waterstaat, and there is a special corps of engineers devoted to that branch of their profession.

The chief works of drainage have grown with the exigencies of the case. At first very slight dikes would be required, but as the land was drained and occupied it settled, making it necessary to increase the height and size of the dikes, and also carrying the surface of the water in the ditches lower and lower, until the sluices were no longer able to drain it off, and the erection of pumps and windmills to drive them then became a necessity. This mode of driving pumps has been the favorite one in the Netherlands for various reasons. The country is flat and the winds that sweep over it are strong and steady, furnishing an abundance of power at a cheap rate. Steam engines, which are their chief

competitors, require fuel, which is expensive, and in times of disturbance might not be easily obtained.

In wet seasons, or in still weather, when the mills could not work, the land suffered much. This led to the growing of such crops as are least injured by water, and hence pastures and meadows are much more common than fields of grain or other cultivated crops. For the best of pasture and meadow the water in the ditches only needs to be kept 18 inches below the surface of the soil, while for growing grain or other cultivated crops to the best advantage the water must be kept 3 feet below the surface. Though windmills, then, would furnish the cheapest power, there were seasons when the country suffered greatly for want of an agent more under control. Especially was this the case where lands were entirely under water and needed to be pumped dry before any improvement could begin. It is said that 90 lakes have been drained in Holland, and while some of the smaller could be pumped dry by windmills, the larger ones needed the steady power of steam. One of the greatest engineering works of the age is the draining of Haarlem Lake, a large body of water which lay but a short distance southwest of Amsterdam.

*"The origin and history of this great enterprise is as follows: In the year 1539 the North Sea, long restrained by artificial dams and dikes, as well as by some natural ridges of sand, suddenly burst its barriers and brought horror and desolation into the fertile flats of North Holland. Twenty-six thousand acres of rich pasture land, with meadows, cattle, and gardens, were covered by the waves, and the village of Nieuwenkirk was submerged and all its inhabitants lost, in the tremendous calamity. The inundation resulted at first in the formation of four lakes, but the barriers of soft alluvial soil which separated them were gradually destroyed, and the four lakes became merged into one. The degradation of the shores also continued until, at the commencement of the eighteenth century, the waters covered an area of 45,000 acres, with an average depth of 13 feet below low water in the Zuyder Zee. This lake constituted what has since been known as the Haarlem Meer or Sea. The people of Holland saw with much alarm the rapid extension of its boundaries, and at an expense of about $160,000, succeeded in partially arresting its progress; an expense of about $20,000 per year was moreover entailed for the preservation and repair of the works of defense. More than two centuries elapsed after the time of the first inundation before any one began to dream of recovering this vast tract of country, and then, for a long period, all plans proposed were deemed impracticable. At length, on the 9th of November, 1836, a furious hurricane from the west drove the waters of the lake upon the city of Amsterdam, and drowned upward of 10,000 acres of low land in the neighborhood. On the 25th of December following, another hurricane, from the east, drove the waters in an opposite direction upon the city of Leyden, the lower parts of which were submerged forty-eight hours, and 19,000 acres of land were inundated. The enormous loss occasioned by these two storms induced the Government to determine on the drainage of the lake, and a credit of $3,200,000 was voted by the States General. In May, 1840, a commission was appointed to superintend the work.

"The first operation was to cut a canal round the lake, to isolate it from the neighboring waters and to afford the means of navigation to the enormous traffic which previously passed over the lake, amounting

*Ann. Sci. Disc., 1853, p. 31.

to 700,000 tons per annum. This canal was 37 miles long, 130 feet wide on the west and 115 on the east side of the lake, with a depth of 9 feet of water. On the side next to the lake the mouths of all water-courses entering it were closed by earthen dams, having an aggregate length of 3,000 yards, made in 10 feet depth of water. Other great works were executed by enlarging the sluices at various points, and erecting powerful steam engines to assist in discharging the water from the canal during the time of high water. The water of the lake has no natural outlet, being below the lowest practicable point of sluiceage. The area of water inclosed by the canal was rather more than 70 square miles, and the quantity to be lifted by mechanical means, including rain water. springs, leakage, &c., during the time of drainage, was estimated at 1,000,000,000 tons. In determining the motive power to be employed, two points were to be kept in view: first, the cost of draining the lake; second, the cost of annual drainage; for, when once the work was accomplished, the site of the lake could only be kept dry by mechanical power. With the exception of a few steam engines, the wind had hitherto been the motive power employed to work the hydraulic machines used in the Netherlands to keep the country dry. And the power of 12,000 windmills, having an average aggregate power of 60,000 horses, is required to prevent two-thirds of the kingdom from returning to the state of morass and lake from which the indomitable energy and perseverance of the Dutch people have rescued what is now the most fertile country in Europe.

"The Haarlem Meer commissioners were convinced that the old means must be laid aside, and new ones adopted to suit the magnitude and peculiarities of their work. They accordingly determined to erect three gigantic steam engines of a peculiar construction, which was accordingly done, and the whole put in operation in 1848. These engines consume but 2½ pounds of coal per hour for each horse-power, and are capable of raising 112 tons of water 10 feet high at each stroke, or of discharing 1,000,000 tons in twenty-five and a half hours.

"A short description of one of these engines may prove interesting. It has two steam cylinders, one of 84 inches diameter, placed within another of 144 inches diameter; both are fitted with pistons; the outer piston is of course annular, and the two pistons are united to a great cross-head, or cap, which is furnished with a guide rod, or spindle; both pistons and cross-head are fitted with iron plates, and together, with parts of the engine attached, have an effective weight of nearly 90 tons. The engine-house is a circular tower, on the walls of which are arranged 11 large cast-iron balance beams, which radiate from the center of the engine. Their inner ends, furnished with rollers, are brought under the circular body of the great cap, and their outer ends are connected to the pistons of 11 pumps of 63 inches diameter each; the stroke of both ends is 10 feet, and the discharge from the pumps 66 cubic meters or tons of water per stroke.

"The action of the engine is very simple; it is on the high-pressure, expansive, condensing principle. The steam is admitted first beneath the small piston, and the dead weight of 90 tons is lifted, carrying with it the inner end of the pump balances, and of course allowing the pistons to descend in the pumps.

"The equilibrium valve then opens, and the steam in the cylinders passes round to the upper surface of the small and annular piston, puts the former in a state of equilibrium, and presses with two-thirds of its force upon the annular piston, beneath which a vacuum is always maintained; thus the down stroke of the engine, and the elevation of the

pump pistons and water, is produced by the joint action of the descending dead weight in the cap and pistons and the pressure of steam on the annular piston. The engine has two air-pumps of 40 inches diameter and 5 feet stroke each. The water is lifted by the pumps into the canal, from which it passes off towards the sea sluices. The total weight of iron employed for the engine, pumps, &c., is 640 tons. The cost of the machinery and buildings was $175,000.

*"The last openings in the surrounding dike were closed in the beginning of June, 1848, and one engine was started on the 7th of that month. The water in the lake then stood at 25½ inches below the Amsterdam Level.† On the 11th it had been lowered to 32½ inches, and after thirty days' operation the water stood at 3 feet below. In October the level was reduced to 3 feet 1½ inches, which left the banks exposed to all kinds of danger from the approaching stormy season. The two other engines were set at work February 26, 1849. In one year's time they brought down the surface of the water to 6½ feet below A. P. By this time some difficulty was experienced in bringing the water to the engines, on account of its shallowness near the shores. Two of the engines stood almost exactly at the opposite ends of the lake, and a conducting drain was dug between them, which divided the lake into two nearly equal parts. A cross-drain was also dug, cutting the first at right angles. They were cut to the full breadth of 65½ to 82 feet, but only to the depth of 10 feet, and later to that of 13 feet, equaling the average depth of the Meer, which was for the time satisfactory. Afterwards these ditches had to be lowered to 19¾ feet, and in 1857 they were deepened to 21⅓ feet. The last portions of water were troublesome to drain off to the pumps, and the engines could only work intermittently. In June, 1852, the water of the Meer finally disappeared, and in July the ground became quite dry. The work thus lasted four years and one month, but as only one engine worked for the first part of the time, it is considered that the whole is equivalent to three years and seven months' work of the three engines.

"The first engine made an average from 8 to 9 strokes a minute, and the other two an average of from 6 to 7, and in the whole time nearly 14,000,000 strokes each. The whole amount of water that was raised was 832,000,000 tons.

"The total expense of the undertaking, from 1839 to 1855, inclusive, has been $3,600,000. The land was at first valued at $33 an acre. Subsequent examination proved that the soil laid bare by the draining operations was of far greater value than was originally supposed. Thus, in 1853, 1,936 acres brought $230,000, or $118 per acre, and though subsequent sales have not realized such large prices, yet the land commanded a much higher price than the first valuation. 'This result,' says M. D. Endergrest, 'surpassed all expectation, inasmuch as the grand object of the drainage was rather to put an end to the encroachments of the lake than to make a lucrative speculation of it.' It is stated that a great number of farms are springing up on all sides, and that the cultivation of the rich land is affording employment to many hundreds of laborers. The total amount of land available for agriculture is estimated at 44,400 acres; and by proper care and supervision it is confidently expected that no water overflows will take place.

"The value of the land recovered by Holland from the Lake of Haar-

* From Buysing's Waterbouwkunde.

† The datum plane to which all levels are referred in Holland is on a level with an established point of reference in Amsterdam. This mark is usually spoken of as A. P. (Amsterdam Peil).

lem is increasing at a rate which insures payment of all the outlay for the drainage in a comparatively short time.

"No ill consequences were experienced from intermittent fevers, as was dreaded when the surface was first laid bare, and the numbers of dead fish had no other effect than to fertilize the soil."

A visit to this dry lake in 1870 proved very interesting. It is traversed by excellent roads, the ditches are kept clear, and the water is low in them, about 3 feet below the surface. Farm-houses are located everywhere about the bottom of the lake, and trees, shrubs, and all the appendages which belong to pleasant and prosperous farmers' houses are found here just as though they were not beneath the level of the sea. For some years after the lake was drained, the lowest parts continued wet and unpromising, and the land was held at a low price, but by reducing the drainage-level still further, this portion has become quite as dry as any part of it, and the soil being heavier it is now more valuable than any of the rest. With the exception of some strips along the edge, from which the peat has still to be cut or burnt off, every acre is now productive. I saw here one of those remarkable Dutch dairies—the cow-stables, cheese-house, and dairymen's dwelling all under the same roof, and all perfect models of neatness.

The yearly expense of keeping this Haarlem Meer Polder * dry is not great. My informant, who was a land-owner in it, told me that his taxes there were 10 florins per hectare, and that they were 7 florins per hectare, in one of the small lakes which he had drained. These prices are equivalent to $1.62 and $1.13 an acre, which is not high for the work done and the valuable service rendered in always having a full supply of water only 3 feet below the surface.

The success of this enterprise has led to the undertaking of several others of the same kind, and to the projection of still more. The great ship canal now in course of construction between Amsterdam and the North Sea passes for 12 miles of its length through the Y, a large body of water which is about 4 feet deep. The canal is built by dredging out the material and depositing it in the banks on either side. After this is done it is designed to pump out the water from the rest of the Y, and thus to secure 12,000 acres of good land. This is considered entirely practicable, and the company estimate the reclaimed land to be an important part of their compensation.

The Zuyder Zee, though covering a large surface, is quite shallow, and the project of diking it off from the North Sea, and then pumping the water out of it, is now under discussion. The work is one of great magnitude, and must take a long time to get it into operation, but it is neither impracticable nor visionary. The whole of it covers an area of 1,200 square miles; but part of it may be divided off for completion at first. The Haarlem Meer Polder includes 18,000 hectares, which this year are worth 1,200 florins per hectare, or nearly $200 an acre; and the whole is worth 21,600,000 florins, or $8,640,000.

The following rules in regard to the construction of dikes are copied from Storm Buysing's Hydraulics, the standard text-book for Dutch engineers:

"*Form of dikes.*—Dikes in general should have height enough to turn water; and by their form and the material of which they are made, they should possess strength enough to withstand the pressure which water and other forces bring to bear against them. Hence they should rise at least from 20 inches to 2 feet above the highest known level of the

* "Polder" is the Dutch name for a plot of reclaimed ground surrounded by a dike.

water. Their shape should be that of a trapezium. They must be made of good adhesive earth, and they must not only be mutually united together in all parts, but also with the foundation on which the dike is laid. The breadth of the top may vary from 19 inches up to 20, 23, and even 26 feet. The outer slope has an inclination of from 2 to 8, and even 10 base to 1 rise. The inner slope is just enough to hold up the earth; usually from 1½ to 2 base to 1 rise. It may even be necessary in some cases to give the inner slope a curved outline.

"*The fore shore.*—The dikes are generally separated along their outer and inner borders from the adjacent lands by ditches, and the spaces between the ditches and the foot of the slopes are called the outer and inner berme. The breadth of these vary; for the outer berme 33 feet, and for the inner one 20 feet, is usually thought sufficient. Sometimes these bermes are left as the natural surface of the ground raised them; but in case the land is not smooth and regular, they are often brought up to a uniform height, when they aim to lay them with a gentle slope, say 1 in 20, from the bank outwards, so as to facilitate the running off of surface water.

"Experience shows that the dikes which lie directly on the brink of the shore are much more liable to injury than those which lie further in and have some land before them; and however much ideas may differ about the minimum of breadth in the different circumstances, which depend upon the position, yet all are agreed as to the supreme importance of this protection; and in laying out new dikes and diking new polders this must be looked to.

"Most of our existing systems of drainage lack this protection, and lie directly exposed to the force of the waves or current; yet these dikes once had land in front of them at most points, but it has been slowly worn away by the action of water. Now, to change the situation of the dikes is impossible, and we must limit ourselves to the employment of the best means of defense, and regulate these according to the situation.

"In laying out new dikes the first consideration is that the species of earth be suitable for making and keeping them up. Material for the outer dikes must be had without coming nearer to the dike than the outside line of the berme; that is, along the shore an edge of unbroken earth must be left of from 33 to 66 feet wide; and at intervals of perhaps 325 feet jetties or projecting banks of earth 20 feet wide, standing out at right angles to the line of the dike, should be left to supply material for the repair of the dike, filling holes, or for other uses of the like character.

"Along the banks of great rivers, and along the sea-shore, the berme or foreshore is sometimes made much wider, even to 325 or 490 feet.

"*Location.*—In selecting a location for dikes on new ground there are many more circumstances to be considered than for determining the foreshore: First, the direction must be such that with the shortest dikes the greatest surface possible may be inclosed; second, the dike must, as far as practicable, run parallel with the stream or else at right angles to it; and, third, that direction must be avoided which would be exposed to our prevailing storm winds from the southwest, west, and northwest. But above all, the quality of the ground on which to found the dike must be considered, and the firmest and highest possible selected, and that which is not cut up by brooks or low ground. When corners or tongues of land come in the way, it is to be decided whether their outline should be followed, or partly cut through and diked, as in cases where the cost of a longer dike may not be compensated by the increased value of the piece of land to be diked. The line of the dikes

must avoid all acute angles, and when necessary making them outward rather than inward, because they hold the water driven by the wind better than the others. Different lines can be united by curves, to which the two are both tangent.

"For the cross-section of a dike it is not enough to obtain strength, but sufficient strength to resist the force of the water on the dike must be obtained at the lowest possible cost. The height forms the first consideration; the highest water levels ever to be expected at that point form the guide to this, and observations of extraordinarily high freshets after storms give them. Those of January 14 and 15, 1808, February 4, 1825, and February 24, 1837, are the highest ever known, and rose as high as 7½ to 8¼ and even 9 feet above the ordinary high-water mark, varying with the position as regarded wind at the point of observation. These heights were measured with perfectly smooth water; the waves are by no means equal. Where dikes turn from the wind there are scarcely any waves, so that a dike from 2 to 2½ feet above the highest known water level is quite sufficient for these. While in dikes affected by the storm wind, the waves rise, according to observations taken in Zeeland, as much as 8 feet above still water. The waves are higher where the dike is without a berme and has great depth, than where it has a high and broad berme. They also rise on steep slopes much higher than on more gradual ones.

"The height of the dike must be most regular, sloping from those points most menaced by waves down to such parts of the dikes as are protected from the wind, where less height is requisite.

"For example, the Southern Dike, between Rammekens and Veissingen, on the island of Walcheren, is only 10 feet above high tide, while it rises at Veissingen to 16¼ feet. The Westkappel Dike, which is also very favorably situated with regard to the wind, is 15¼ feet above high-water mark.

"On the island of Schourien, when the dike of Scharrendijke was improved in 1842–'43, it was raised to 21 feet above high water. Other less exposed portions along the Zeeuw streams are from 10 to 11¼ feet above.

"The Helder Sea Dike from the end of the dunes at Huisduinen on to Nieuwe Diep, running almost east and west, and consequently much exposed, is from 12½ to 15½ feet above ordinary high tides; the other North Holland dikes along the Zuyder Zee are from 11 to 12 feet. The Gelder and Overyssel dikes average from 11 to 12½ feet; those in the vicinity of Vollenhoof are 13 feet above, and those along the coast of Groningen from 13 to 15¼ feet above.

"The height above ordinary high and low water thus regulates the height given in descriptions and plans, and this is indicated by immovable marks at different points, such as bolts, beams, or panels in sluices, or similar things. The ordinary tides are 13 feet or less.

"The breadth of the top of the dike varies from 20 inches to 20, 23, or 26 feet. The first consideration here is the strength required of the dike, and the second whether the top shall or shall not be used for carriages and horses. Riding on top of the dike is generally considered as injurious to the dike and dangerous for the traveler; nevertheless, it seems advantageous to give so much breadth to the tops of the dikes that they may serve as roads when needed; for in time of danger they are often of great service for the transportation of materials, while in case of overflows they afford communication for a long time when the ordinary lower roads are made impassable by the water. Hence, where the ordinary roads do not cross dikes a breadth of at least 10 feet should

be left, while on such as usually serve the purpose of roads from 16 to 20 feet is necessary.

"On the inner side, that slope is taken at which the soil is in no danger of sliding down; the most cohesive soils will almost stand with a slope of 1 base to 1 rise, less cohesive, 1½ to 1. If the dikes had only to resist the pressure of the water on their sides, then (providing the dike were of good adhesive material) the cross-section might be triangular in shape, the side slopes of which should have the natural inclination of the earth; but this is not advisable, since perfect coherence and solidity are never attainable in a raised mass of earth, and this lack must be supplied by a greater amount of earth. Again, the jar of the water and the motion of the waves form the chief cause of the destruction of dikes, and hence the outer slope, which has first to resist this force, must be put in condition to withstand it.

"The force with which water and other bodies come against a slope increases in proportion to the angle made by the slope with the horizon; hence a slight inclination affords more resistance than a steep one, which experiments have confirmed.

"According to theories advanced by Woltman on the effects produced by water and ice upon dike slopes, sea dikes are effectual with less strength at their foot than nearer the top, and a convex surface should be chosen for the outer side of sea dikes, though a smooth form should be retained where the slope varies but little.

"The consideration that the ice is never driven by low water against the dikes, but always at high tide, and that the beating of the waves against these dike slopes can be injurious only when the winds are in a certain direction and at high tide, naturally leads to the conclusion that the slope below high-water mark may be less smooth than above. As the portion of the slope below high water is unfavorable to a natural covering of grass, it must be artificially protected, and this protection is less costly with a steep slope than with a gentle one. As all sudden crossings and sharp angles are to be avoided, the outer slope should have a convex form.

"The species of earth of which the dikes are made must be such as will cohere and hold firmly to the foundation; the more cohesive the earth the more desirable it is, and the more solidity may be expected from the dike. Hence clay is the most desirable material for dikes, and it can generally be found along our coasts where dikes have been or must be laid. Sometimes they are made by preference from alluvial earth, where clay is not near, and its transportation would be too costly and troublesome.

"Sand has very little cohesiveness, and will not make strong water-tight dikes; pasture or marshy earth has too little specific gravity, frequently even less than water, and hence must be excluded with sand from the dike.

"Garden and surface soil, though far below clay, still, as its fine particles readily pack, is much more desirable than pasture ground or sand, particularly for covering slopes where grass is wanted.

"The clay is not always pure, nor always obtainable in sufficient quantities, so that a mixture of clay and poor earth must often be used. But if care is taken to put the best and purest clay on and near the outer slope, and the poorer kinds in the body of the dike, then such kinds may be used without much danger. There are instances of dikes made from very sandy soils, with a covering of only 3 feet of clay on the outer slope, which, nevertheless, turned water well. Such layers of clay should be used with the utmost care, and every little injury must

be immediately repaired, for if the ground once give way so far as to admit the water to the sand or poor earth, little dependence can be placed upon stopping the water.

"Before commencing the making of the dikes direction, and profile are carefully marked out on the ground, and the precise borders of the inner and outer banks marked with a sharp instrument. Within these the sods are torn up as much as possible, and the ground always dug up deep 7 to 8 inches, made soft and cleared from all roots of trees, plants, or anything which might hinder the proper cohesion and union of the soil. The sods, both from under the dike and from the ditch, are to be carefully piled up to be afterwards used in covering the new work. As the outline of the dike and size of the ditch are enlarged, it will seem that the new dike is to be higher than that previously calculated for, for the earth is not so firmly united when first dug out as it subsequently becomes through the weight of the dike and the evaporation of the water, but the subsoil will also be more or less pressed down by the weight of the dike until the resistance of this packed subsoil equals the weight imposed. It is difficult to give a definite idea, as the position of the foundation depends upon the nature of the ground, the weight of the dike, and the extent of the surface necessary to support this weight. The greater or less sinking of the body of the dike depends partly on the greater or less firmness and humidity of the soil, but also much upon the carefulness of its treatment. So the height of the dike is made one-seventh or one-tenth greater according as more or less sinking is expected, but the breadth of surface remains the same that it is to be after the final settling of the height of the dike, so that the inclination of the two slopes is steeper. But since the top of the dike will sink most, as most earth is heaped there, and the ground has at just that point to bear the most weight, while, on the contrary, there is no sinking at the foot of the slope, after its final settling the dike will have less inclination.

"The banks are built in thin layers and packed by the constant passage of horses and carts, and sometimes by means of stamps or by puddling.

"The planting of dikes with trees may be very advantageous. Along genuine sea dikes it is impossible to keep them alive, but dikes less immediately exposed to the sea air are often planted with trees. The rapid drying of the dikes renders the growth of wood slow, and the grass grows thin and poor under them; while the motion of the trees in high winds, affecting the roots, loosens the soil, so that it seems unadvisable to plant dikes where trouble in resisting the water is anticipated. Whenever there is an opportunity to plant osiers and willows along the dike, at a distance of 20 or 26 feet, such planting is highly desirable, for it destroys the power of the waves and of the ice, thus strengthening the dike. The osiers and willows are generally cut every three or four years. In order that the dike may never be exposed, an arrangement ought to be made to cut a part every year, so that the larger portion of the protection may remain standing."

APPENDIX No. 2.

REPORT OF COL. WILLIAM LUDLOW ON THE DRAINAGE OF KINGSESSING AND TINICUM MEADOW DISTRICT.

PHILADELPHIA, *August* 18, 1884.

GENTLEMEN: In compliance with your request I have given such careful preliminary consideration as the information at hand has permitted to the question of the proper system of drainage of the lands of the Kingsessing and Tinicum Meadow Company.

In order to reach an entirely satisfactory solution of the problem, there should be an accurate topographical map of these lands, showing not only their exact boundaries and those of the adjacent and inclosed properties not controlled by the company, but in particular the elevation of the surface above low water, or some other convenient plane of reference, in order that the actual contours and slope of the lands may be seen and studied, and the most suitable lines of drainage be determined.

In such matters exact information is of the greatest value to those charged with the responsibility of recommending or making expenditures, and in the greater number of cases the cost of such surveys is more than saved at a later period by the avoidance of errors and the more advantageous use of the funds available.

In the present case I have had for guidance only general maps of the land, without lines of levels or surface elevations shown thereon, but the deficiency in the information furnished by the maps I have endeavored to supply, for the purpose of this report, by a careful personal inspection of the meadows under consideration. Furthermore, I have been familiar for many years with the history and characteristics of these lands, having had charge of the Government properties at Fort Mifflin and Fort Delaware and been a frequent visitor to these and similar meadows on the Delaware River.

In general it may be said that the meadows present broad stretches of arable lands with a nearly level surface, which lies below the plane of mean high water in the river, and that they have been converted from valueless wastes of marsh, overflowed at every tide and frequented only by gunners, into extensive tracts of highly fertile and productive meadows suitable for habitation and the cultivation of crops.

This reclamation has been brought about by the construction of dikes, which, following approximately the line of low water, border the streams and protect the meadows from the incursions of the tides, even those of much more than the average height.

Assuming the meadows to be approximately 2 feet on the average below the level of mean high water, with an average rise and fall of tide in the Delaware of 6 feet, the land surface will be about 4 feet above the level of mean low water in the river; and were suitable provision made for the lowering of the ground water to this level, it is evident that there would be an average depth of 4 feet of dry land, with the im-

portant and valuable result that the meadows would thereby be thoroughly and permanently reclaimed, under the fortunate conditions of being in no danger of drought, since any deficiency could be readily supplied from the higher level of the surrounding streams, while the full native fertility of the soil would be developed by the acquired moderate dryness and porosity.

It is evident that such a result would largely increase the value of the lands and their products. There are at the present time two principal causes operating against this desirable transformation, viz, the rainfall, which is at times excessive, and the defective system of drainage which has hitherto been pursued.

Owing to these causes the level of the ground water, instead of being 4 feet below the surface of the meadow, as it might be, is only from 1 to 2 feet lower, and often less, producing a disadvantageous wetness of soil, frequent excess of moisture, and injury to the crops. The amount and distribution of the rainfall are of course beyond control. Its annual average is about 42 inches, equal to 3½ inches per month, and in certain months the fall may reach so much as 6 inches or even 7 inches; but, were the conditions of the land as above described, it is quite safe to assume that the 4 feet of dry and porous soil would be entirely capable of absorbing the surplus rainfall, from which it would gradually free itself by evaporation and conversion into vegetation. It remains therefore to consider the defects of the existing system of drainage, and to indicate the means of amending them.

As at present arranged this system consists of a footing ditch lying just inside the dike, whose sinuosities it follows, while the interior drainage of the tract is directed by other channels and ditches of greater or less dimensions, and more or less obstructed from natural growth of vegetation and neglect, which convey the surplus water to the footing ditch.

The final discharge of drainage water into the flowing streams is intended to be secured by sluices extending from the interior footing ditch, under and through the dike, to the outer stream. These sluices are somewhat rough constructions of wood, 6 to 8 feet in width and 1 to 3 feet in depth, reaching through the dike, with a hinged flap at the outer end which is designed to open to a pressure from the inside and close against the rise of water level on the flood. While theoretically providing for the escape of the land drainage and guarding against the inflow of the river water, in actual operation these sluices have two radical defects.

The first is one of construction. It is practically impossible to make a valve of this rude kind water-tight, and whenever the outer level of the water is higher than the inner, there is a certain amount of leakage past the flap and through the sluice into the footing ditch. This will be clearly understood when we consider the mechanical skill and knowledge required in the design and manufacture of the water-gates and valves used in hydraulic constructions, where the most careful and exact planing and fitting of metal surfaces, supplemented by the exercise of a considerable force to bring them into close contact, is necessary in order to make them tight. Furthermore, it is evident that the flap would in general be unable to free itself from any obstruction, such as a stick or bunch of weeds which, either by accident or design, should prevent it from closing, and the valve would therefore remain open during the entire tide, and be admitting water under the full pressure of the outer level. Water-rats, too, seek such places to burrow through the dike, following the sides of the sluice, and making holes, through which water enters with greater or less freedom.

It is evident, therefore, that under the most favorable circumstances the sluices could not be expected to entirely exclude the tidal water, while the absence of careful supervision offers an opportunity for them to admit more water than they could possibly discharge. This brings me to the second defect of the sluice, which is a fundamental one not susceptible of remedy.

Assuming the land surface to be 4 feet above low-water level, and the ground water 2 feet lower, it is manifest that there would be no discharge through the sluice until the tide has fallen to below 2 feet above low water. The tide falls 6 feet, and if it fell uniformly at the rate of a foot an hour there would be but two hours of the ebb tide out of six, or, including the subsequent flood, four hours out of twelve, during which the sluice would discharge. As a matter of fact the proportion is even less than this, since the changes of water level in tidal streams, particularly on the flood, are generally more rapid near low water than at other stages. The sluice will, therefore, be in favorable action at the best only about one-third of the time, and the outflowing current will move only with the moderate velocity due to the comparatively small average difference in level during that time.

Were all the drainage water accumulated near the sluice and the discharge opening made sufficiently large, the effect would be more favorable, but in fact the drainage water is required to flow for considerable distances through the footing and drainage ditches in order to reach the sluices, and therefore fails to escape before the tide has again risen.

It must also be remembered that frequently from freshets or the effect of winds, the tides are held up, and occasionally for days together fail to fall to their ordinary level.

It is evident, therefore, that the sluices from their defects of construction, and especially from the limited and uncertain time of their operation, cannot be depended upon to effect any such thorough and satsifactory drainage of the meadows as would dry out the soil and develop their full value; and I have no hesitation in saying that if these lands are to be made reliably and permanently productive it must be by some more radical and effective means than those now employed. In this view of the subject we are not without most valuable guidance and instruction. The Dutch have for a century or more been masters of this branch of engineering, and their work of reclaiming lands from the sea has been the most daring and successful, and on the largest scale of any in the world.

At the mouth of the Scheldt, for example, the swiftest river in Europe, with a current of 4 to 8 knots an hour and a rise and fall of tide of 15 to 20 feet, they have not hesitated to construct their dikes in 50 or 60 feet of water, and to compel the sea to permanently relinquish numerous tracts of many thousands of acres, lying in some cases several feet beneath the level of low water. In order to develop the fertility of these, it is recognized that the level of the ground water must be kept down, and that if this be perfectly provided for the rainfall offers no difficulty. The dikes are therefore made of the most solid and massive character to prevent filtration, and the drainage is provided for entirely by pumps—both wind and steam. These usually raise the water into a "bosom" or reserve area whence it may be discharged, but which is not emptied in order that the water may be conveniently restored to the meadows in case the rainfall should at any time prove insufficient.

The fertility and productiveness of the reclaimed lands of Holland under these circumstances are renowned; but there is no reason to believe that they are intrinsically superior to those of the Delaware mead-

ows, if properly developed. In regard to these, some instructive experience has already been gained in the great improvement in the condition of the meadows which has taken place at Fort Mifflin and on Black's Island during the last six or eight years that I have known them. Under my direction on Mud Island, and Mr. Black's on his own property, the dikes along the Delaware have been greatly raised and strengthened, the sluices which admitted the water have been almost entirely dispensed with, and the footing ditches entirely so. The result shows beyond question that, as the Dutch knew long ago, the principal enemy is the river water, and that if its absolute exclusion can be secured by the construction of massive and unbroken dikes, no apprehension need be felt of inability to deal with the other adverse influences.

I am therefore prepared to advise the eventual abandonment of all the sluices and the substitution therefor of pumps; but, recognizing the importance of not entering upon too great an expenditure at the outset, I submit the following as embodying my preliminary recommendations on the subject.

The Back Channel, which was formerly a deep though minor channel of the river, but having been blinded many years ago at its Schuylkill mouth has been steadily shoaling, still contains a considerable body of water, and has a sluice at the Delaware mouth.

I have not exact information, but assuming a length of 1 mile, an average width of 15 yards, and an average depth of 1 yard, it now contains about 25,000 cubic yards or 5,000,000 gallons of water.

The channel should be entirely closed at its Delaware end by a double line of tight sheet-piling, and a pump put in operation to empty the channel, continuing the work until the water shall cease to flow to the pump and the level of the ground water at remote points is lowered to a desirable degree, say about the level of low water in the river. At Long Hook the same thing should be done, closing the sluice, making the bank tight, and setting a pump. My impression is that the amount of water in Long Hook is less than in Back Channel, but that a considerable amount of infiltration through the Darby Creek dike will increase the quantity of water to be handled until this is stopped. These two will, in all probability, be all the considerable pumping stations required. As rapidly as possible all sluices should be abolished. As opportunity offers the footing ditches immediately in rear of the dikes should be filled up, and if constructed at all should be laid out 100 or 150 feet farther back in order to allow of greater width to the dike and prevent filtration and the burrowing of rats. When convenient, a dredge with a long boom or movable chute to land the mud should work along the dikes to raise and strengthen them where required on the Schuylkill and Darby fronts, letting the material flow back upon the meadows, as has been done on the Delaware front.

From the fact that Gravel Sluice receives considerable water from the upland about Paschall, it may be necessary temporarily to make some moderate provision for pumping at this point also, but all other discharging points will in the end be abandoned.

If Mingo be connected with Long Hook, and a channel of moderate dimensions be kept open, only the two main pumping stations, viz, Back Channel and Long Hook, will have to be operated, and it is entirely possible that by establishing suitable connection between these two but one will ultimately be required. A final conclusion on these points depends upon the exact ascertainment of the slope of the ground and the results of the pumping operations.

The pumps are to accomplish two objects, viz, to remove the ground water and thereafter to keep it down. The former is the only one re-

quiring any considerable expenditure of power, as the rainfall will for the greater portion of the year be not much in excess of what will be required.

I would therefore urge that a competent person be employed under proper instructions, to make the necessary surveys with levels, and occasional borings, to determine the character of the ground and the precautions that should be taken to make the foundations of the dikes water-tight. Should, for example, a portion of the dike be found to rest upon a gravel or other permeable bed, a large amount of water might make its way beneath the surface and increase the work of the pumps. Until this survey has been made, and the grounds topographically mapped, it is not practicable to satisfactorily determine what will be the most favorable and economical drainage arrangements.

For the operations of the first year, which include the removal of the ground water, two pumping stations are necessary, one for Back Channel and the other at Long Hook. These for the present should be steam pumps of about 30 horse-power each, and they should be in operation not later than the 1st of October, in order to get the ground water well down before the hard-freezing weather. Operations would continue during the winter as might be practicable, and in the spring the pumps should be run regularly in order to have the ground in perfect condition for the spring planting.

During the summer but little pumping will be required, as the evaporation and growth of the crops will absorb the greater part of the rainfall. A windmill pump with an Archimedean screw will then take the place of steam with a large economy in the expense of maintenance, and thereafter will be found ample to take care of any surplus water that may be due to rainfall.

I estimate the cost of constructing and operating the two steam stations at from $6,000 to $7,000 for the first year, and if the river water be thoroughly excluded by closing all the sluices and making the dikes perfectly tight, it is probable that little or no pumping will thereafter be required. It would perhaps be advisable to erect two windmills to take the place of the steam-pumps, but the probabilities are that there will be a deficiency of water rather than an excess, and that it may be necessary to draw water from the river in order to keep the crops supplied.

The windmills should be constructed at a cost of not to exceed $1,200 each, completely equipped for service, and when in full operation and the level of the ground water satisfactorily reduced, the steam-pumps could be disposed of at a fair percentage of their cost.

Some ditching will be necessary in order to properly provide for the interior drainage of the company's tract, but the details of this part of the work must await the completion of the survey.

The dikes should be strengthened beyond possibility of overflow and infiltration. They should be put in grass, all trees and shrubbery removed, no weeds permitted to grow, and no cattle allowed to graze—their feet make holes which are harmful.

I would recommend also the employment of an intelligent and reliable man, whose sole business it should be to supervise all matters relating the drainage, examine the dikes, see that no leakages exist, keep the banks in repair, and observe the working and effect of the pumps.

I am entirely satisfied that with proper system the value and productiveness of the meadows would be increased by an amount many times the cost of the expenditures necessary for their thorough reclamation.

Respectfully,

WILLIAM LUDLOW.

Messrs. N. W. HARKNESS and E. N. BLACK.

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